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LIFE-CYCLE COSTING OF LIFE SUPPORT EQUIPMENT

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NOTICES

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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A feasibility study has been accomplished on applying life-cycle costing (LCC) to aircrew life support equipment (LSE). The AFLC Logistics Support Cost (LSC) model was examined and found to be too complex for application to life support devices (LSD). A potentially useful simplification of the LSC model was developed and applied to the CRU-68 oxygen regulator and the FR139 and FR140 anti-G valves, but available logistics data were insufficient for these devices. An alternate model (LCC-LSD) was developed and applied with some success. The simpler computer program requires data much more accessible from the D041,

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20. ABSTRACT (Continued)

D039, and D062 data systems and has a plotting capability to graph LCC vs. changes in reliability or maintainability. Sensitivity analyses showed maintenance costs to be the key area where the U.S. Air Force could achieve significant savings (perhaps $15 million).

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LIFE-CYCLE COSTING OF LIFE SUPPORT EQUIPMENT

INTRODUCTION

Objective

This report describes work performed as a continuation of an earlier research project to show the feasibility of costing the life cycle of life support equipment. The earlier research resulted in the development of an elementary model to calculate this life-cycle cost (LCC). Information from the earlier research report that is essential to understanding the new work will be included here.

The goals of this research project are to --

1. Provide a capability in the model for handling repair both at local bases and at depots.

2. Include programmed depot maintenance (PDM) in the model even when the devices are still in safe operating condition.

3. Add a feature to the model that will discount costs over the lifetime of devices.

4. Obtain data on transit, repair, and remove/install times, and enhance the capability of the model to handle the data.

5. Obtain data on the number of bases using life support equipment and apply the model to several such items, subject to the availability of data.

The achievement of these goals will enhance the methods used by the U.S. Air Force to study the LCC of life support equipment. In particular, using a computer implementation of the model will enable the Air Force to make design decisions for life support items to reduce the LCC of such equipment.

Analyzed Items

The earlier research project analyzed a Model CRU-68 oxygen regulator and anti-G valves Models FR139 and FR140. This report includes updated analyses of those items as well as analyses of the following items:

Anti-G suit, Model CSU-13/P
Oxygen mask, Model MBU-5/P
Oxygen connector, Model CRU-60/P

We were unable to acquire data on the newer oxygen regulator, Model CRU-73.

LOGISTICS-SUPPORT-COST MODEL OF AIR FORCE LOGISTICS COMMAND (AFLC)

One major objective of the earlier study on LCC was to determine the feasibility of applying the AFLC Logistics Support Cost (LSC) Model to life support equipment. If that model proved to be unfeasible, then an attempt was to be made to determine if developing a usable model was within the state-of-the-art.

The first step in this task was to thoroughly review the LSC model as presented in the user's handbook. This handbook describes such things as basic modeling techniques, details of the LSC model, and computer application of the model. Of major interest in this handbook were the ten equations that collectively make up the LSC model.

The ten equations were analyzed and evaluated for applicability to life support equipment. This analysis yielded a modified set of equations that seemed reasonably appropriate. Seven equations were eliminated from our consideration because they either required data not readily available, were relative to fixed assets such as facilities, or did not apply due to configuration (for example, engines and fuel consumption). No attempt was made to alter the current LSC approach, but merely to ascertain the feasibility of its application for life support equipment. Appendix A gives the three applicable equations from the LSC model. The feasibility of using the LSC model came down to determining the availability of the data required for these three equations. The availability and appropriateness of the data will be discussed in the "Availability of Data" section.

OTHER AIR FORCE APPLICATIONS OF LCC MODELS

The Air Force is taking an [illegible] interest in applying LCC to systems acquisition. The introduction of the new programmable calculators has provided a tool that allows LCC evaluation of design and support options. The key advantage of this tool is that it shortens the feedback loop for information on LCC impacts. An LCC model for use with the TI-59 handheld calculator has been developed. (A user's handbook is available through the Directorate of Cost Analysis, Comptroller, ASD, Wright-Patterson AFB, Ohio 45433.) This model does not include the following costs:

- Training equipment and services
- Documentation
- Facilities
- War-readiness material

Our evaluation of this model indicated that it is basically the same in theory, right down to the LCC equations, as the LSC model that we concentrated on for this study.

Two Air Force programs have recently utilized LCC. The ACES-II ejection-seat program used the AFLC LSC model for source selection. The Survival Avionics System had The Analytic Sciences Corporation develop an LCC model to evaluate the combined cost of acquiring modern systems and supporting them over their operational life.

AVAILABILITY OF DATA

A computer, no matter how sophisticated, is only as good as the data input to it. Our investigation into the LCC of life support equipment has shown that the data needed for such effort is, at best, "somewhere in the system." It was exceedingly difficult to decipher what many variables represented, what the units were, and what relationship existed between the data maintained at collection points and the variables named in the LSC model equations. An example of this in various equations is the MTBF parameter--identified as mean time between failures, in operating hours. This parameter is not applicable to all life support items because some get removed for other reasons, such as expiration of calendar months. Another example is PFFH, or peak force flying hours. It is defined as the expected fleet flying hours for 1 month during the peak usage period. This term had no apparent data source.

According to our findings, data relative to things such as mean time to failure, cost of repair, and man-hours to repair are maintained at the various Air Logistics Centers of AFLC. The San Antonio and Oklahoma City centers were visited so that relevant data could be collected.

The primary sources of data turned out to be the following computation systems: the D041 Recoverable Consumption Item Requirements, for the oxygen regulator and valve; the D039 Equipment Item Requirements, for the anti-G suit; and the D062 Economic Order Quantity Buy, for the oxygen mask and connector.

The D041 system computes replenishment spares requirements for certain items. Failure, replacement, condemnation, and other reliability rates are mechanically and manually developed on the basis of past usage and program data accumulated over a set time period. This time period may be based on flying hours, calendar months, programmed depot maintenance, or engine overhauls.

Recoverable items not routinely serviced at depot level are handled by the D039 system. Item-by-item details on this equipment are not kept at depot level, but general information regarding number in service, in inventory, and in place at each base is available at depot level. These items may be repaired or adjusted at base level, and only a local record of repairs or adjustments is kept.

The D062 system is used for unrecoverable items. These items are accounted for at the depot level to the extent of the number on hand, number on order, past demand history, and reorder level. Although the status of items at the depot is known in considerable detail, items beyond the depot are out of the accounting system. The only link between the two sets of items is the history of demands. That is, the number of items for replacement is known, but the rate of replacement is not known. D062 equipment may be repaired at base level; but if such repair is not feasible, the item is condemned at base level and not returned to the depot.

The first research project concluded that it was not feasible to use the Air Force Logistics Command LSC model to analyze the LCC of the oxygen regulator and valve (D041 system). Because data required for the LSC model was not available in a form we could use and was not always appropriate for life support equipment, we devised a simple LCC program for direct use on the D041 data.

Early in this second research project, we had to decide whether to use the model developed for the D041 items or to pursue a different method to analyze the LCC of the new items--the anti-G suit and the oxygen mask and connector. After reviewing the available data for the new items and their maintenance strategies, we decided that this model was appropriate for the analysis and would be our life-cycle cost for life support devices (LCC-LSD) model.

Interpretation of the factor printouts proved to be time consuming and difficult. After comparing information gleaned from the printouts with comments from people involved in Air Force logistics, we concluded that the factor printouts should be used as guidelines or approximations but not as exact representations of equipment systems.

PROGRAMMED DEPOT MAINTENANCE

One effect of PDM on the LCC-LSD model is to change the demand rate; i.e., PDM-imposed overhauling of items before they fail results in smaller mean time between demands (MTBD). PDM should also result in lower repair costs because inspection of items while still in operating condition should reduce the number of potentially expensive major failures.

PDM could be included in the LCC-LSD in two ways. The first is to supply two different demand rates, one for PDM and one for item failure; then determine the cost for a PDM overhaul and the average cost of repairing a failed item. From this information, calculate the annual PDM maintenance cost and the annual failed-item maintenance cost and use these costs in an incremental LCC analysis.

The second method is to sum the PDM demand rate and the failed-item demand rate and get an average demand rate. Then calculate an average maintenance cost for the two demand types. The average demand rate is used to find the number of annual repairs. Multiplying this number by the average maintenance cost gives annual maintenance cost.

The LCC-LSD model does not include a specific PDM input or analysis. PDM is mentioned in the D041 information system instruction manual, but the D041 factor printout only gives percent of items undergoing PDM that are found to be defective. PDM is not used for the D039 or D062 items analyzed in the research.

CHANGES IN LCC-LSD COMPUTER PROGRAM

The following changes have been made in the original LCC-LSD model:

> A breakdown of bases into two groups, continental United States (CONUS) and overseas, and corresponding modification in transportation time.

An added capability to provide present-worth analysis at user-specified interest and inflation rates.

A modification to allow depot and base repair capability together, as opposed to only base or only depot repair capability.

An added plotting capability, called at the user's discretion, to give graphic display of model output.

A new multiple-run capability with variable MTBD and repair time.

A change of some classifications from standard data to input data to recognize differences between items.

These changes are discussed in detail in the "Incremental LCC-LSD Model" section.

Transportation Times

Some changes have been made in the LCC-LSD model so that transportation information will more accurately model the actual supply cycle. Transportation times depend upon the priority assigned to the items to be shipped. Low priority is usually given for the items investigated in this report, so transportation time associated with low priority is used in the program. The time delay from day of base requisition to day of base receipt is 28 days, of which 13 is the time of actual travel. These times represent the maximum expected. The 28 figure is now used for "base-depot transit delay" standard data for CONUS bases only. For bases overseas (including Alaska and Hawaii), an additional 38 days is required, for a total of 66 days. The 66 figure is now used for overseas "base-depot transit delay" standard data.

Because of the substantial travel time difference between CONUS bases and those overseas, the total number of bases where an item is used must be separated into these categories. The program then takes the extra travel time into account when calculating base and depot inventory levels.

Present-Worth Analysis

The capability of present-worth analysis is included in the LCC model for use in justifying changes in initial costs. For example, present-worth analysis can show the net dollar result of increasing the manufactured first cost so that future maintenance savings can be realized. A present-worth analysis will find the present, equivalent lump-sum amount of future annual expenditures. By comparing the present worth of costs of two different designs, a clear-cut selection of the design with the lowest incremental LCC can be made.

The program also allows for an analysis with inflation included. The effect of inflation on the future purchasing power of dollars may have some bearing on how much should be spent now. Therefore, the three options available to the user are:

A. No present-worth analysis

B. Present-worth analysis without inflation

C. Present-worth analysis with inflation

Option A may be sufficient for a general cost analysis of a new or existing item. Option B is probably best to use when comparing changes in existing item designs when inflation of prices is not significant. Option C is used to analyze costs in significant inflationary situations.

The logic behind finding the present worth of annual expenditures of savings is based on the fundamental formula

$$PW = A\left[\frac{(1+i)^N-1}{i(1+i)^N}\right] \tag{1}$$

where: PW = present worth of equal yearly payment amounts
A = yearly payment, or annuity
N = number of years
i = annual interest rate

For an LCC analysis, the annuity equals the annual maintenance cost which consists of the repair costs and the cost of new items due to condemnations. The annuity is calculated in the program with N equal to the analysis period of the item, but i is input by the user.

The formula for inflation-affected present worth is a derived formula based on the interactive effect of inflation and interest every year. The formulation is as follows:

$$PW = A\sum_{n=1}^{N}\left[(1+i_f)^n(1+i_r)^{-n}\right] \tag{2}$$

where: i_f = inflation rate
i_r = interest rate

This finds the combined effect of each year of inflation and interest and then sums up this yearly effect over the years of analysis. The remaining steps are simply mathematical manipulations of this formula.

$$PW = A \sum_{n=1}^{N} \left[\frac{1+i_f}{1+i_r} \right]^n \tag{3}$$

Substituting $X = \frac{1+i_f}{1+i_r}$ in eq. (3) gives

$$PW = A \sum_{n=1}^{N} X^n \tag{4}$$

The solution to this series is known to be

$$X + X^2 + X^3 \ldots + X^N = \frac{1-X^{N+1}}{1-X} - 1 \text{ for } X \neq 1 \tag{5}$$

which leads to

$$PW = A \left[\frac{1-X^{N+1}}{1-X} - 1 \right] \tag{6}$$

Replacing X with $\frac{1+i_f}{1+i_r}$ gives

$$PW = A \left[\frac{1-\left(\frac{1+i_f}{1+i_r}\right)^{N+1}}{1-\left(\frac{1+i_f}{1+i_r}\right)} - 1 \right] \tag{7}$$

Just as with present-worth analysis explained earlier, the user inputs the inflation rate, interest rate, and the number of years. The annuity is calculated in the program as total annual maintenance cost.

Eq. (3) is infeasible for X = 1. This condition occurs when the inflation rate equals the interest rate. However, it can be seen that equation (2) reduces to

$$PW = A \sum_{n=1}^{N} 1^n \tag{8}$$

$$PW = A \times [1^1 + 1^2 + 1^3 + \ldots + 1^N] \tag{9}$$

$$PW = A \times N \tag{10}$$

Plot Capability

The revised LCC-LSD program has the capability to plot graphs of total cost vs. man-hours to repair at base or total cost vs. man-hours to repair at depot. Either plot may also be graphed for up to three different values of MTBD per graph.

In Appendix B, Figure B-1 is the standard output from the LCC-LSD program for the left-hand anti-G valve. The third line under the heading "Data Unique to Item" indicates that the time between demands is in hours. Whenever a plot is requested by the user, one standard output for the first combination of variables will be printed, followed by a table listing the values for the first and all other combinations of variables, as shown in Figure B-2. Figure B-3 shows a graph of the total cost in dollars vs. base man-hours (BMH) to repair for this valve. Three plots are shown, each for a different MTBD. The data necessary to obtain a plot is described in the "Data Input Format for LCC-LSD Computer Program" section, but a brief interpretation of input will be given here.

For each program execution, the user may choose to print or not print a graph. If a graph is not chosen, the user does not need to input any further graph data. If specifying that a graph be plotted, the user needs to input the number of MTBD values, up to a maximum of three.

The first MTBD value used will always be the one calculated from item input data. The user specifies the desired MTBDs as a fraction of the MTBD calculated from item input data.

The input for man-hours to repair is similar but not identical. The user may choose between base man-hours or depot man-hours and then specify how many man-hour values are to be plotted. Then the user specifies a fraction that will be used to calculate the man-hour values. For example, assume that the user specifies a base man-hour plot, five values are desired, and the fraction is .08. The five base man-hour values will be:

(1) The input value for BMH = 4
(2) 0.92 x 4 = 3.68
(3) 0.84 x 4 = 3.36
(4) 0.76 x 4 = 3.04
(5) 0.68 x 4 = 2.72

The purpose of the graphing capability is to provide a fast visual aid to interpreting changes in incremental LCC due to various values of base repair man-hours, depot repair man-hours, and mean time between demands. The graph should not be used as a detailed illustration of incremental LCC.

Changes in Standard Data

In addition to transportation input changes mentioned earlier, other information previously assumed to be standard is now variable--requiring user input for each item. These changes occurred because of differences between so-called standard data for items investigated and in anticipation of variation in future data. Information that has been changed to be user-defined includes:

(1) Depot repair days
(2) Base repair days
(3) Flight-hours per day per item
(4) Depot procurement days (times from ordering new items from supplier to receiving items from supplier)
(5) Lifetime of item

Including this information as input data will save the user from having to change the actual program code in the future.

For a group of similar items, the model allows for a percentage of total repairs to be completed at base and a percentage at depot. The user inputs the percent of item repairs done at base. The total demand for repairs can then be broken down into the number of items repaired at base and the number repaired at depot. The model incorporates a transit delay between base and depot to insure an inventory sufficient to meet demands at the desired confidence level.

Of all the items studied, only the D041 equipment (oxygen regulator and anti-G valves) had repairs at depot. The D041 factors printout gives the percent of items repaired at base and at depot.

Investigation of Cost Parameters

Investigation into several related cost parameters--namely, transportation, inventory, and cost of condemnation--indicated that specific costs for individual items cannot be determined in most instances or that the cost contribution is negligible. Transportation costs as a whole are grouped among many different items, making them indeterminable for specific items.

There are two types of transport costs. First are the costs associated with shipping from contractors/suppliers to the depots. Funds for this transportation come from a large general transport fund. Individual items are not accounted for; money is simply extracted from the fund as needed for shipments. However, personnel at Wright-Patterson AFB tack a general 3% increase onto the unit price of an item and call it the "standard price." This 3% surcharge is described in the D039 and D041 study guides as "first destination transportation." Therefore, the initial transport is represented in the computation system outputs for D039 and D041 items. Whether or not the same procedure is used on D062 items is not clear.

The second type of transport costs are those associated with shipping from depot to base and vice versa. These shipping costs are not assignable to specific items and cannot be readily estimated. Shipments going to a base are accumulated for a week and usually consist of a variety of items. All modes of transportation are used; therefore, shipping rates depend on different factors at different times. Since shipments are groups of mixed items and different forms of transportation are used, creating one rate based on weight or space occupied would be very complicated and was beyond the scope of this study.

Inventory holding costs may be available at depot level, but we could find no one with such information. We doubt that this information exists at base level.

Condemnation costs, the cost of activities associated with condemning an item, are reported as negligible. According to a base equipment specialist, condemning an item consists of writing out a condemnation tag, ordering another item from the depot, and disposing of the condemned item.

INCREMENTAL LCC-LSD MODEL

Use of the Model

The incremental LCC-LSD model is used to evaluate changes in the incremental LCC of a life support item as a function of reliability, maintainability, and attendant unit cost. LCC-LSD uses data obtained from the D039, D041, and D062 data systems.

The only costs included in LCC-LSD are those that are strongly sensitive to changes in reliability, maintainability, and unit cost. They include:

(1) Cost of the installed items
(2) Cost of required inventories at bases and depot
(3) Maintenance costs, including costs of replacing condemned items.

Items considered to be relatively insensitive to changed reliability and maintainability (e.g., cost of support equipment, personnel training, technical data, and facilities) are not included. We consider it better to minimize the amount of input data that must be used.

Our simplified model, nonetheless, presents some intricacies on data input. The D041 data system gives demand rates for some items, such as the anti-G valve, as the number of demands (repairs) per 100 unit flight-hours. With a demand rate of 0.5, 200 flight-hours on each of 50 units in a given month would produce 0.5(200)(50)/100 = 50 units to be repaired in that month.

The demand rate for other items, such as the oxygen regulator, is considered more susceptible to calendar time than to flight usage. The demand rate for such items is given by the D041 data system as the number of demands per calendar month per item installed. A demand rate of 0.02 for 25,000 items installed would produce 0.02(25,000) = 500 units to be repaired or overhauled in 1 month.

Provision is made in the LCC-LSD model for selecting the appropriate mode of expressing the demand rate for a given-type item. The D041 data system indicates the mode through the Program Selection Code (1 = per 100 flight-hours, 3 = per month). D039 and D062 items must be studied individually to determine the demand-rate mode. Usually, an equipment specialist at a depot or base can provide information as to the proper demand mode.

Model Description

Figure 1 shows the procedure used by the LCC-LSD model in determining the incremental LCC of a device. A computer program that embodies this procedure is listed in Appendix C. The essential logic of that program is shown as a flow diagram in Appendix D.

CALCULATE:

1. Mean time between demands
2. Demands per year
3. Base items: (a) Condemned
   (b) Repair
   (c) Base-depot repair
4. Inventory level for base
5. Depot items: (a) Condemned
   (b) Repair
6. Inventory level for depot
7. Initial costs: (a) Installed
   (b) Base inventory
   (c) Depot inventory
8. Annual costs: (a) Base repair
   (b) Depot repair
   (c) Remove and replace
   (d) Repair parts
   (e) Condemnation replacements
9. Total incremental LCC over lifetime of system.

Figure 1. Model for formulation of incremental life-cycle cost.

Two simplifying assumptions need to be stated before describing the model. The first is that all using bases have the same number of installed items. Such a situation will probably never exist, but without this assumption the model, especially for large numbers of bases, would bog down in data acquisition and be significantly more complex. The second assumption is that as soon as a unit is condemned, a new one is ordered from the supplier. Although this rarely happens, the assumption simplifies the model without distorting the results.

An item to be analyzed falls into one of two categories with respect to demand rate: (1) flight-hour dependent; (2) calendar-month dependent. The components of Figure 1 for flight-hour-dependent items will be explained first, followed by a description for calendar-month-dependent items.

Items with Flight-Hour-Dependent Demand Rates

Calculate MTBD: Take the reciprocal of the demand rate, OIMD (given in demands per 100 flight-hours per item), and multiply by 100, as follows:

$$\text{MTBD} = 100/\text{OIMD} \tag{11}$$

Calculate Demands per Year (PP): Let

DMFH = flight-hours per day
TI = total items installed.

Then the quotient

$$\text{PP} = \frac{\text{DMFH} \times \text{TI} \times 365}{\text{MTBD}} \tag{12}$$

gives the demands per year.

Calculate Base-Condemned Items (BCOND): This value represents the average number of condemned units at a base at any time. Use the following equation to calculate BCOND:

$$\text{BCOND} = \frac{\text{DMFH} \times \text{BSDT}}{\text{MTBD}} \times \frac{\text{TI}}{\text{M}} \times \text{CONDC} \tag{13}$$

where:

M = number of bases
BSDT = time (days) from requisition by base equipment specialist to receipt of new item from depot
CONDC = condemnation rate, stated as fraction of demands

BSDT has two values--one for CONUS bases, another for overseas bases--hence two values of BCOND are calculated. Using CONDC in this equation implies that all condemnations are made at base. This simplifies the model without significantly altering the results.

Calculate Base-Depot Repair Items (BRPD): Some items have repairs performed at depot level. BRPD is the average number of items moving between a base and depot for repair at any time. The formula for finding BRPD is

$$BRPD = \frac{DMFH \times BSDT}{MTBD} \times \frac{TI}{M} \times (1-PERC) \times (1-CONDC) \tag{14}$$

where:

PERC = fraction of repairs done at base
(1-PERC) = fraction of repairs done at depot
(1-CONDC) = fraction of demands that are repairable

To accommodate both CONUS and overseas bases, two values of BRPD are calculated.

Calculate Base Repair Items (BRPB): This value represents the average number of items undergoing repair at a base at any time. The equation is

$$BRPB = \frac{DMFH \times BRCT}{MTBD} \times \frac{TI}{M} \times PERC \tag{15}$$

where:

BRCT = the span of time (days) from removal of an unserviceable item from an end article at base level until the item has been repaired at base level and is ready for reissue.

Calculate Inventory level for Base (STKB): Having items in base inventory to satisfy base demands is most desirable. Therefore, an inventory level sufficient to meet demands at a desired confidence coefficient must be determined.

Assuming that the time between demands has a negative exponential distribution, the Poisson distribution may be used to calculate the desired inventory level. Let X be the demand. The P(X=x) for the Poisson distribution is given by:

$$P(X=x) = \frac{e^{-\mu}\mu^{x}}{x!} \tag{16}$$

where:

μ = the mean value of the distribution, or for the model, the average demand.

From eq. (16), the $P(X \leq x)$ is given by:

$$P(X \leq x) = P(X=0) + (X=1) + \ldots \tag{17}$$

$$\ldots + P(X=(x-1)) + P(X=x)$$

Let $\alpha = \sum_{i=0}^{x} P(X=i)$. Then, if being 99% sure of meeting the demand from inventory is desired, x must be found such that the following is true:

$$P(X \leq x) = 0.99 = \alpha \tag{18}$$

$$0.99 = \frac{e^{-\mu}\mu^0}{0!} + \frac{e^{-\mu}\mu^1}{1!} + \ldots \tag{19}$$

$$\ldots + \frac{e^{-\mu}\mu^x}{X!}$$

$$= e^{-\mu} \sum_{i=0}^{x} \frac{\mu^i}{i!} \tag{20}$$

where:

$$\mu = BCOND + BRPD + BRPB.$$

STKB is given by the value of x that satisfies eq. (20). Two values of STKB must be calculated: one for CONUS bases, one for overseas bases.

Calculate Depot-Condemned Items (DCOND): DCOND is average number of items on order by depot at any time due to condemned items. (Base condemns item; depot instantly orders replacement.) It is given by:

$$\text{DCOND} + \frac{\text{DMFH} \times \text{DPDT} \times \text{TI}}{\text{MTBD}} \times \text{CONDC} \tag{21}$$

where:

DPDT = the span of time (days) from requisitioning an item from the supplier to receiving the item at depot.

Calculate Depot-Repair Items (DRPD): DRPD is the average number of items undergoing repair at depot at any time. When the depot sends an item to a base in exchange for an item needing repair, the item needing repair is sent to the depot and repaired; then this repair item is available for reissue. This span of time (days) is given by DRCT. Two values of DRCT are necessary: one for CONUS bases, one for overseas bases. The equation to calculate DRPD is:

$$\text{DRPD} = [(\text{DMFH} \times \text{DRCTU}) \times (\text{TI} \times \frac{\text{MC}}{\text{M}} \times (1\text{-PERC}) \times (1\text{-CONDC})]/\text{MTBD} \tag{22}$$

$$+ [\text{DMFH} \times \text{DRCTO}) \times (\text{TI} \times \frac{\text{MO}}{\text{M}}) \times (1\text{-PERC}) \times (1\text{-CONDC})]/\text{MTBD}$$

where:

DRCTU = CONUS DRCT
DRCTO = overseas DRCT
MC = number of CONUS bases
MO = number of overseas bases

In the current program the input DRCT is the CONUS value and the program adjusts for the overseas base.

Calculate Inventory Level for Depot (STKD): To calculate STKD, use eqs. (18), (19), and (20), with μ equal to

$$\mu = \text{DCOND} + \text{DRPD} \tag{23}$$

and STKD is the value of x that satisfies eqs. (18), (19), and (20).

Calculate Initial Costs Installed (CTALLD): This is the number of items installed, multiplied by UC--the unit cost of an item. This represents the cost of buying enough items to exactly fulfill all in-use requirements.

Calculate Initial Base Inventory Costs (CINIBS): This is given by

$$\text{CINIBS} = [(\text{STKBO} \times \text{MO}) + (\text{STKBU} \times \text{MC})] \times \text{UC} \tag{24}$$

where:

STKBO = calculated base inventory level for an overseas base
STKBU = calculated base inventory level for a CONUS base.

CINIBS is the cost for filling the inventory at base level when initiating a new system.

Calculate Initial-Depot-Inventory Costs (CINID): CINID is the cost for filling the inventory at depot level when initiating a new system.

$$\text{CINID} = \text{STKD} \times \text{UC} \tag{25}$$

Calculate Annual Costs of Base Repair (CREPB): This value consists of two amounts. The first is the amount spent annually to repair items at bases. The second is the annual cost of condemning items, where the cost to condemn one item is assumed to be the same as the cost to repair one item at base level.

$$\text{CREPB} = [(\text{PP} \times \text{CONDC}) + (\text{PP} \times (1\text{-CONDC}) \times \text{PERC})] \times \text{BLR} \times \text{BMH} \tag{26}$$

where:

BLR = base labor wage rate per hour
BMH = base man-hours to repair an item.

Calculate Annual Costs of Depot Repair (CREPD): Any item not repaired at base nor condemned at base is treated as being repaired at depot.

$$\text{CREPD} = \text{PP} \times (1\text{-CONDC}) \times (1\text{-PERC}) \times \text{DLR} \times \text{DMH} \tag{27}$$

where:

DLR = depot labor wage rate per hour
DMH = depot man-hours to repair an item.

Calculate Annual Remove-and-Replace Cost (CRANDR): When an item fails, it must be removed from the host equipment and replaced with a good item. The time required for this is called "remove and replace" time. The annual cost is given by:

$$CRANDR = PP \times RMH \times BLR \tag{28}$$

where:

RMH = man-hours to remove and replace an item.

Calculate Annual Repair Parts Cost (CPARTS): CPARTS does not include replacement of condemned items. Only repair kits or parts are included.

$$CPARTS = PP \times (1\text{-}CONDC) \times (UC \times BMC/100) \tag{29}$$

where:

BMC = cost of repair parts or kits (as a percent of unit cost)

Calculate Annual Condemnation Replacement Costs (CCONDM): This is the cost of buying replacement items from suppliers:

$$CCONDM = PP \times UC \times CONDC \tag{30}$$

Calculate Total Annual Costs (CANUMA):

$$CANUMA = CCONDM + CPARTS + CRANDR + CREPD + CREPB \tag{31}$$

Calculate Total Incremental LCC over Lifetime of System:

$$CTOILC = CTALLD + CINIBS + CINID + (LFT \times CANUMA) \tag{32}$$

where:

LFT = Lifetime of item (years).

Items With Calendar-Month-Dependent Demand Rates

Many calculations performed for flight-hour-dependent items are identical to those for calendar-month items. Equations that must be changed are described below.

MTBD:

$$MTBD = 1/OIMD \tag{33}$$

where:

MTBD is in months
OIMD is in demands per calendar month per item.

PP:

$$PP = \frac{12 \times TI}{MTBD} \tag{34}$$

BCOND:

$$BCOND = \frac{BSDT}{MTBD \times 30} \times \frac{TI}{M} \times CONDC \tag{35}$$

BRPD:

$$BRPD = \frac{BSDT}{MTBD \times 30} \times \frac{TI}{M} \times (1\text{-}PERC) \times (1\text{-}CONDC) \tag{36}$$

BRPB:

$$BRPB = \frac{BRCT}{MTBD \times 30} \times \frac{TI}{M} \times PERC \tag{37}$$

DCOND:

$$DCOND = \frac{DPDT \times TI}{MTBD \times 30} \times CONDC \tag{38}$$

DRPD:

$$DRPD = [DRCTU \times TI \times \frac{MC}{M} \times (1\text{-}PERC) \times (1\text{-}CONDC)]/(MTBD \times 30) \tag{39}$$

$$+ [DRCTO \times TI \times \frac{MO}{M} \times (1\text{-}PERC) \times (1\text{-}CONDC)]/(MTBD \times 30)$$

DATA INPUT FORMAT FOR LCC-LSD COMPUTER PROGRAM

In this section the input format for data required by the LCC-LSD program to perform an incremental LCC analysis for an item is described. Examples of applying the program to the D041, D039, and D062 data bases are given in the next section, along with a table describing the location of required data in the various data-base printouts. The rest of this section will show proper placement of the data on each type of data card and how to arrange the cards in an input deck.

Card Type	Description	Format
1	Plotting option - NPLOT NPLOT = 0, no plot NPLOT = 1, plot results	I1
2	Title Any combination of alphanumeric characters. Column 1 MUST be blank.	80A1
3	No. of values of MTBD - NM Fraction of original MTBD desired - C(2),C(3) NM = 1 if only MTBD calculated in program is to be used on the plot; C(2) and C(3) are not used. Example: 1 Column No. 1 NM = 2 if MTBD calculated in program is to be used for the plot, and the fraction of MTBD given by C(2) is to be used for the plot; C(3) is not used. Example: 2.85 Column No. 1234 NM = 3 if MTBD calculated in program is to be used for the plot, and two fractions of MTBD--given by C(2) and C(3)--are to be used for the plot. Example: 3.85 .70 Column No. 123456789	I1,2F5.2

Card Type	Description	Format
4	Number of values of BMH or DMH desired on plot - NH Fraction of original value by which BMH or DMH decreases with each run - PNT Selection of BMH or DMH - NSEL NH $\leq$ 10 PNT $\leq$ (1/NH) NSEL = 1 BMH will be varied and shown on plot NSEL = 2 DMH will be varied and shown on plot Example: 3 .10 2 Column No. 23 8 Three values of DMH will be plotted: DMH, 0.9 x DMH, 0.8 x DMH	I2,F5.2,I1
5	Type of present-worth analysis - INTANA Interest rate - INT Inflation rate - IFR INTANA = 1 No present-worth analysis; INT and IFR are not used. INTANA = 2 Present-worth analysis without inflation; IFR is not used. INTANA = 3 Present-worth analysis with inflation; INT and IFR are used. Example: 38.0 5.0 Column No. 23 9 INTANA = 3; INT = 8%; IFR = 5%	I2,2F6.2
6	Demand index - ID Total number of items installed - TI Lifetime of item - LFT Number of CONUS bases - MC Number of overseas bases - MO Percent of items repaired at base - PERCNT ID 1 = Demand is flight-hours dependent ID 2 = Demand is calendar-months dependent PERCENT $\leq$ 100.0 Example: 1 4364 10 13 2775. Column No. 5 10 15 20 2256	5I5,F6.2

Card Type	Description	Format

ID = 1 MC = 13
TI = 4364 MO = 27
LFT = 10 PERCNT = 75

7 Man-hours required to repair item at base - BMH 8F10.5
Man-hours required to repair item at depot - DMH
Man-hours required to remove and replace an item - RMH
Demand rate for item - OIMD
Unit cost for item from supplier - UC
Confidence coefficient for inventory - SIGMA
Cost of repair parts or kits, as percent of unit cost - BMC
Percent of failed devices that are unrepairable and are condemned - COND

OIMD: Given in failures per unit time indicated by ID.

For ID = 1, demands per 100 flight-hours per item
For ID = 2, demands per calendar month per item
SIGMA < 1.00

Example:	4.	3.	1.5	.0031
Column No.	1	1	2	3
		1	1	1

Example:	316.7	.99	67.	16.5
Column No.	4	5	6	7
	1	1	1	1

BMH	= 4	UC	= $316.70
DMH	= 3	SIGMA	= 99%
RMH	= 1.5	BMC	= 67%
OIMD	= 0.0031	COND	= 16.5%

8 Days to repair at base - BRCT 4F10.5
Average flight-hours per day per device - DMFH
Number of days to receive a new device from supplier at depot - DPDT
Days to repair at depot from CONUS base - DRCT

Example:	6.	1.5	270.	12.
Column No.	1	1	2	3
		1	1	1

BRCT = 6 DPDT = 270
DMFH = 1.5 DRCT = 12

If more than one type of item is to be analyzed, type-2 through type-8 cards are presented for each additional item to be analyzed. A data deck has only one type-1 card.

If the plot option is not selected, type-3 and -4 cards may NOT be omitted. They may be blank; but if they are not, the data on these must be in the correct type-3 or type-4 format. This allows the user to run programs with or without plots without having to constantly remove or insert plot-information cards.

If a value is not specified, it will default to zero due to using FORMAT statements to input data.

APPLICATIONS OF LCC-LSD MODEL

D041 Items

The many changes made to the original LCC-LSD model prompted another cost analysis of the D041 items--the anti-G valve and the CRU-68 oxygen regulator. In addition to presenting updated input and new cost results, this section provides detailed documentation of where to locate needed input information.

The cost results from the updated information differed from those of the original, not so much due to program changes as to rather significant changes in input information. In the case of the regulator, the influential factors appear to be the cost of repair (increasing from 70% to 81% of unit cost) and a decrease in condemnation rate (from 3% to 2%). Since most regulators are repaired at the depot, the increased repair rate puts a greater demand on depot inventory. The fact that the overall cost increased $3.2 million (7.5%) over the analysis completed a year ago indicates that a careful watch must be kept on input information.

Originally, the right-hand and left-hand anti-G valves were combined to form one set of data. The present analysis was conducted on each valve separately because of substantial differences between the two. When the individual valve cost results are combined, the net amount is $240,000 (20%) less than the original. The great difference in MTBD was handled originally by using the higher figure to represent both right and left valves. By separating the MTBD to respective valves, a more accurate cost analysis is obtained.

Turning attention to Figure B-4 (Appendix B), the detailed costs are shown after an echo of the user input information. The list of costs on the top left-hand side is the user information in summary. The list on the top right-hand side is the standard information built into the program and not affected by user input. Notice that the breakdown of costs (bottom half of output) also includes relevant numerical information regarding size of inventories and number of maintenance actions. The initial inventory costs are separated into base and depot, and each component contributing to yearly maintenance is represented. The annual maintenance cost is multiplied by the analysis period, and a total incremental LCC is presented. The LCC-LSD output for the left-hand anti-G valve is shown in Figure B-1; and for the right-hand valve, in Figure B-7.

Table 1 is a detailed guideline for finding the necessary information to run the LCC program for D041 devices. All readily available information is found in the D041 factors printout. The remaining information must be estimated or investigated through an equipment specialist. The phrases within quotes under "Location for D041" in Table 1 are titled sections of information within the factors printout. Figure 2 shows the exact locations of these titled sections.

Several variables deserve explanation to clarify the use of certain numbers or formulas. Information regarding identification of the item tells whether item failures are measured per calendar month or per 100 flight-hours. In the analysis of the regulator and valves, rough estimates have been used for total number of devices in service. The estimates were based on the factor printout section labeled "Total Item Past Installed Program." This section gives total number of flight-hours for all applications of the particular item. Applications are the number of final products (such as aircraft). The number of items per application and the percentage of applications using the item also are considered in the Past Installed Program. The problem is that the number of applications is not given, so basing the number of installed items on the total number of flight-hours creates a high probability of error. The precise numbers of applications apparently exist somewhere because these numbers are necessary to determine total flight-hours of all applications in the factors printout. Investigation into other data base outputs may provide the exact number.

The confidence coefficient of inventories is .99 for all items analyzed in this report. This guarantees that a space will be available in inventory (depot and base) 99% of the time a demand is received. The computer program in Appendix C provides a capability to assure a different confidence coefficient (SIGMA) whenever the average inventory level is less than 50 units. For average levels of 50 or greater, the program will assure 99% confidence regardless of the input value of SIGMA, due to the use of the normal deviate 2.33 in three formulas near statements 660, 670, and 700.

The repair cost represented in the factors printout as "Unit Repair Cost" consists of cost of repair parts and/or kits plus the labor involved. The labor portion of this cost is subtracted out so that labor cost can be identified separately. The revised repair cost is then divided by unit cost and the quotient expressed as a percentage for BMC.

Table 2 describes the input data used for the analysis of the oxygen regulator.

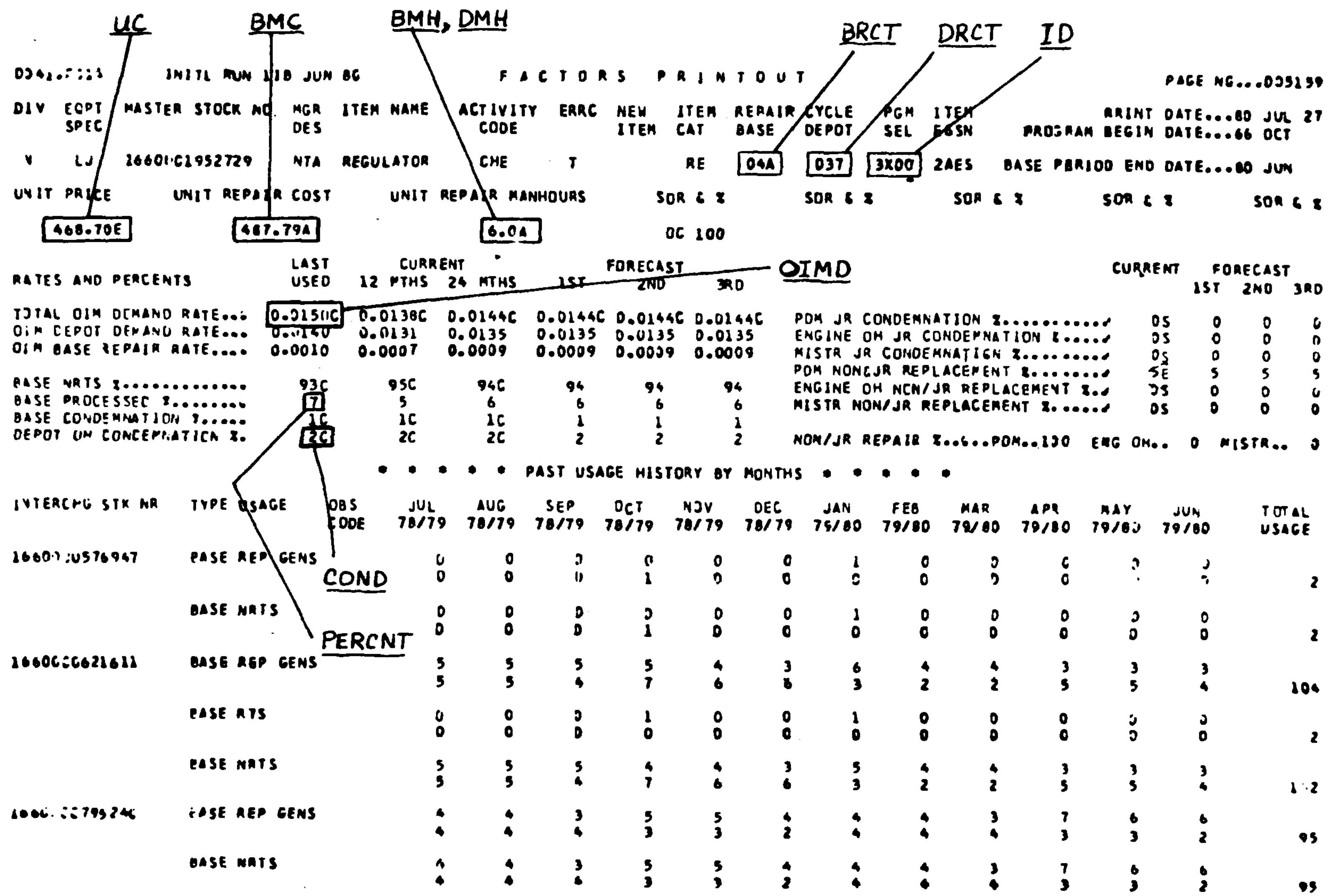
TABLE 1. LOCATION OF DATA ITEMS IN COMPUTATION SYSTEM PRINTOUTS

Variable Description	Input Variable	Location for D041	Location for D039	Location for D062
1. Identification of item-- ID = 1, flight-hours depend. ID = 2, calendar-months depend.	ID	Top row of information - "PGM SEL" First digit: if = 1, hours program if = 3, months program*(1)	Investigate, estimate	Investigate, estimate
2. Total number of items in service	TI	Investigate*(1)	From Format 50, Sec. D, under "Past Qtrs Reported In Use," find average of assets in use over most recent 4 quarters	Investigate
3. Assumed lifetime (yrs)	LFT	Investigate, estimate	Investigate, estimate*(2)	Investigate, estimate
4. Percent of repair work done at base rather than at depot	PERCNT	Under "Rates & Percents," use number for "Base Processed %"	Almost always 100%; some items may have depot repair	Always 100%; no depot repairs
5. Number of CONUS bases using item	MC	Investigate, estimate	Format 100, Sec. 1, lists all bases using item; count those in CONUS	Investigate, estimate
6. Number of overseas bases using item	MO	Investigate, estimate	Count from Format 100, Sec. 1	Investigate, estimate
7. Man-hours to repair at base	BMH	"Unit Repair Man-hours"**	If applicable, investigation needed	If applicable, investigation needed
8. Man-hours to repair at depot	DMH	"Unit Repair Man-hours"**	Most often zero; no depot repairs	Always zero
9. Man-hours to remove item and install new one	RMH	Investigate, estimate	Investigate, estimate	Investigate, estimate

10.	Demand rate for item	OIMD	Under "Rates & Percents," use number for "Total OIM Demand Rate"	In Format 50, Sec. D, use condemnation factor + repair factor--both found under "Rate": top decimal is repair; bottom is condemnation. *(2)	See text, pp. 36-38
11.	Unit cost	UC	"Unit Price"	In Format 250, "Unit Cost" column, "Total w/FDT" row	"Unit Price"
12.	Confidence coefficient of inventories	SIGMA	Usually use .99, otherwise whatever user desires*(1)	Usually .99 (same discussion as D041)	Usually .99 (same discussion as D041)
13.	Cost of repair parts, as percentage of unit cost	BMC	Take number under "Unit Repair Cost"; subtract out labor (labor = repair man-hours x labor rate); express as % of unit cost*(1)	If applicable, investigation necessary	If applicable, investigation necessary
14.	Percentage of devices condemned per year	COND	"Depot OH Condemnation %"	Investigate, estimate*(3)	Usually 100%, unless some repairs made
15.	Time to repair at base	BRCT	"Repair base," top row, use number portion only	If applicable, investigation necessary	If applicable, investigation necessary
16.	Flight-hours per day/ device	DMFH	Investigate, estimate	Investigate, estimate	Investigate, estimate
17.	Time for depot to procure a device from manufacturer	DPDT	Investigate, estimate	In format 250, column "Buy Net Requirements," row "Percent Lead/Mos."	Under "Lead Time," add "Admin" to "Prod"
18.	Time to repair at depot	DRCT	"Cycle Depot," top row	Usually zero; no depot repairs	Always zero; no depot repairs
			All D041 information in factors printout	All D039 information in D039 output - Format 50, Format 100, Format 250	All D062 information in EOQ Computation Notice

*See explanation in text: (1) p. 25, (2) p. 30, (3) pp. 30 and 34

**Investigation necessary to distinguish between depot and base repair hours.



UC BMC BMH, DMH BRCT DRCT ID

D041.:::: INITL RUN 11B JUN 8G F A C T O R S P R I N T O U T PAGE NO...D05159

DIV	EQPT SPEC	MASTER STOCK NO	MGR DES	ITEM NAME	ACTIVITY CODE	ERRC	NEW ITEM	ITEM CAT	REPAIR BASE	CYCLE DEPOT	PGM SEL	ITEM ESSN
V	LJ	16601C1952729	NTA	REGULATOR	CHE	T		RE	$\boxed{04A}$	$\boxed{037}$	$\boxed{3X00}$	2AES

PRINT DATE...80 JUL 27
PROGRAM BEGIN DATE...66 OCT
BASE PERIOD END DATE...80 JUN

UNIT PRICE	UNIT REPAIR COST	UNIT REPAIR MANHOURS	SOR & %	SOR & %	SOR & %	SOR & %	SOR & %
$\boxed{468.70E}$	$\boxed{487.79A}$	$\boxed{6.0A}$	OC 100				

OIMD

RATES AND PERCENTS	LAST USED	CURRENT 12 MTHS	CURRENT 24 MTHS	FORECAST 1ST	FORECAST 2ND	FORECAST 3RD
TOTAL OIM DEMAND RATE....	$\boxed{0.0150C}$	0.0138C	0.0144C	0.0144C	0.0144C	0.0144C
OIM DEPOT DEMAND RATE....	0.0140	0.0131	0.0135	0.0135	0.0135	0.0135
OIM BASE REPAIR RATE....	0.0010	0.0007	0.0009	0.0009	0.0009	0.0009
BASE NRTS %.............	93C	95C	94C	94	94	94
BASE PROCESSED %........	$\boxed{7}$	5	6	6	6	6
BASE CONDEMNATION %.....	1C	1C	1C	1	1	1
DEPOT OH CONDEMNATION %.	$\boxed{2C}$	2C	2C	2	2	2

	CURRENT	FORECAST 1ST	FORECAST 2ND	FORECAST 3RD
PDM JR CONDEMNATION %...........	0S	0	0	0
ENGINE OH JR CONDEMNATION %.....	0S	0	0	0
MISTR JR CONDEMNATION %.........	0S	0	0	0
PDM NONJR REPLACEMENT %.........	5E	5	5	5
ENGINE OH NON/JR REPLACEMENT %..	0S	0	0	0
MISTR NON/JR REPLACEMENT %......	0S	0	0	0

NON/JR REPAIR %....PDM..100 ENG OH.. 0 MISTR.. 0

COND PERCNT

* * * * * PAST USAGE HISTORY BY MONTHS * * * * *

INTERCHG STK NR	TYPE USAGE	OBS CODE	JUL 78/79	AUG 78/79	SEP 78/79	OCT 78/79	NOV 78/79	DEC 78/79	JAN 79/80	FEB 79/80	MAR 79/80	APR 79/80	MAY 79/80	JUN 79/80	TOTAL USAGE
16600:0576947	BASE REP GENS		0 0	0 0	0 0	0 1	0 0	0 0	1 0	0 0	0 0	0 0	0 [illegible]	0 [illegible]	2
	BASE NRTS		0 0	0 0	0 0	0 1	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	2
16600C0621611	BASE REP GENS		5 5	5 5	5 4	5 7	4 6	3 6	6 3	4 2	4 2	3 5	3 5	3 4	104
	BASE RTS		0 0	0 0	0 0	1 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	0 0	2
	BASE NRTS		5 5	5 5	5 4	4 7	4 6	3 6	5 3	4 2	4 2	3 5	3 5	3 4	1[illegible]2
1660.::79524C	BASE REP GENS		4 4	4 4	3 4	5 3	5 3	4 2	4 4	4 4	3 4	7 3	6 3	6 2	95
	BASE NRTS		4 4	4 4	3 4	5 3	5 3	4 2	4 4	4 4	3 4	7 3	6 3	6 2	95

Figure 2. D041 factors printout.

TABLE 2. OXYGEN REGULATOR (D041 INPUT)

Variable	Location	Comment
ID = 2	Fig. 2, ID	First digit of "PGM SEL" = 3, hence ID equal 2
TI = 25,000	--	Investigation done in original analysis (from 1978 data) resulted in estimate of 25,000
LFT = 10		Estimate
PERCNT = 7.	Fig. 2, PERCNT	
MC = 45	--	Estimate made on MC, MO based on 60 total bases used in original analysis
MO = 15		
BMH = 6.	Fig. 2, BMH	
DMH = 6.	Fig. 2, DMH	Investigation necessary to determine if base repair hours differ from depot repair hours
RMH = 1.5	--	Estimated
OIMD = 0.02	Fig. 2, OIMD	Rounded .015 up to .02
UC = 469.00	Fig. 2, UC	Rounded 468.7 up to 469.00
SIGMA = 0.99	--	Assumed safety margin
BMC = 81.	Fig. 2, BMC	Labor cost = 6 x 18.05 = 108.3; subtract from 487.79 (BMC) = 379.49 Percentage = $\frac{379.49}{468.70}$ = 81% of UC
COND = 2.	Fig. 2, COND	
BRCT = 4.	Fig. 2, BRCT	
DMFH = 1.5	--	Estimate, not really pertinent since device is calendar-month dependent
DPDT = 180.	--	Estimate
DRCT = 37.	Fig. 2, DRCT	

D039 Items

Our investigation of the anti-G suit indicates that D039 items can be analyzed with the LCC program for meaningful results. The negligible repair time for the anti-G suit (as for most D039 items) eliminates the need for some basic input information required for analysis of D041 items. This situation causes the presence of zeros for some input variables and output results concerned with maintenance. However, meaningful information for inventory and condemnation costs are still computed leading to a total incremental LCC. The format for input information does not change because of nonrepairable items; it will just contain some zeros. If repairable D039 items are to be analyzed, the same information is required as for D041 items.

Three basic sources of information are required to complete input for D039 items:

(1) Format 50 -- Item Management Data
(2) Format 100 -- Reported Assets/Requirements Details
(3) Format 250 -- Projected Requirements/Assets Summary

Though much of the information does not appear in these format printouts, the critical data do. Our efforts to obtain the missing information in some form of data-base printout were unsuccessful. The indications are that repair data on D039 items are kept if the time and/or cost is significant. Persons more familiar with the data bases may be able to find that information.

Table 1 described how input data for D039 items in general can be obtained. Figures 3, 4, and 5 give the exact locations of printed information on example printouts. A couple of variables from Table 1 require further explanation. The assumed lifetime variable is stated in the table as requiring investigation or estimation. However, Format 50 contains a space for average life expectancy which is computed in most instances by an equipment specialist. For the D039 item analyzed in this report (the anti-G suit), the number was not entered on the printout, so we assume that this information will not be present for future analysis. If the average life expectancy has been investigated and printed, its location will be in section A, line BBBBB, column 66-67 of Format 50.

A major difficulty arises in distinguishing an accurate demand rate (OIMD) for D039 items. A replacement factor given in Format 250 represents average number condemned (per year) divided by average number in use. In essence, it is a condemnation rate. We found, however, that the replacement factor is influenced by misleading figures because it represents all sizes or variations of the master stock number. For example, the anti-G suit supposedly has a .25 replacement factor (according to the Format 250 printout), but investigation proved that the master stock number, 8475005458197, has only a .017 condemnation rate. The factor had been inflated by interchangeable stock numbers, most of which have a condemnation rate of .999 for one reason or another. Therefore, investigation is urged in selecting an accurate demand rate; especially to guard against the inclusion of insufficient data from substitutable or interchangeable stock numbers. The condemnation rate and repair rate are used instead of the replacement factor when repairs are performed on the anti-G suit.

```
I & S MASTER   8475005458197                     80 MAY 31 AS OF 80 MAR 31       FY 81/82-1 U                    EQUIPMENT ITEM D039.I21A
REF 1-6 PAESAA        SAALC        DIV E   IM AA      PAGE NUMBER   46          ITEM MANAGEMENT DATA FORMAT 50 - RCS-LOG-MMA-Q-7129

SEC LINE ACT CCPF GRCUP NSN         NOMENCLATURE              IM CFC      BUDGET CCDE     AGE     SEL     SYS      VEHCTL     EC    AAC   EQUIPMENT
 7  H-12  13                         14-32                     33-39       40-49           50      51      52-53    54-55                  SPECIALIST

 A  AAAAA C  8475005458197          ANTI/G GARMENT,CUTA       MMIIEAA     8400000200      D       B                                   J     DF

                                    PROC     ----LEAD TIME---  MIL/SPEC              DSPL   --FACTCRS--  REPL  TECH DATA   OTHER      AVERAGE
                                    AGENCY   ACM   PROD  PROC  NUMBER                DEF    SPARES REPL  CRIT  COSTS       COSTS      LIFE :MP
                                    14-15    16-17 18-19       20-35                 36     37-39 40-44  45    46-55       56-65      66-67

 A  BBBBB                           AF       CC    10    10    MIL-A-834060                  .00   .2542 A     0000000000  0000000000

                                                                    PROCUREMENT CLEARANCE   METHCD OF REPAIR   REPAIR   SUB-SYSTEM
                                    PMC    PROD   PROC   COMPET   AVAL   IA FREQ  DATE      DEF  FLC CONTR OTH  CYCLE    APPLICATION
                                    14-15  16-18  19-21  22-24    25-27  28-30    31-34     35   36   37    38   39-41    42-56

 A  CCCCC C                         IT     YES    YES    YES      YES             0120           Y                      412A

 I & S        STCCK NUMBER          SUB  P  URD OF USE    CAT   IP   PII  FSC  JMC  SSC  ISS/F  ERRC  U/I    PRICE        SOS     SPC
              14-28                 GP   P                ACTY  ALC  CD   29   30   31   32-34  35    36-37  38-47        48-50   51

 B  01000     8475005458197         AA   E  AAA AAE       TU    SE   G    5    8              U     EA     0000000150   FPZ
 P  02000     8475004892497         AA   C  AAA AAD AAE   TL    SE   J    5    8              U     EA     0000000127   FPZ
 P  03000     8475004851436         AA   C  AAA AAC AAD   TL    SE   E    5    8              U     EA     0000000060   FPZ
 B  04000     8475004206356         AA   E  AAA AAB AAC   TU    SE   E    5    8              U     EA     0000000056   FPZ
 P  05000     8475005595345         AA   A  AAA AAB       TL    SE   E    5    8              U     EA     0000000063   FPZ

 ASSET        STCCK NUMBER          T/AQIRE MAP    N/RPT INSTL REP    MOD    COPA   CTHER TCTAL  IN SVC SERV   TOC    UNSERV TOTAL  FUNDED
 HISTCRY      14-28                 29-34   35-39  40-44 45-49 50-55  56-60  61-66  67-71 LCSSES ASSETS ASSETS ASSETS ASSETS AVAL   O/O

 C  01000     8475005458197         031171  00005  00000 00000 000000 00000  000270 00000 000875 027861 002435 000000 000000 030296 007472
 C  02000     8475004892497             61      C      C     0      0      0     49    10     59      2      0      C      C      2      0
 C  03000     8475004851436              2      C      C     C      0      0      0     0      0      2      0      0      C      2      0
 C  04000     8475004206356              0      0      C     0      C      0      0     0      0      0      0      0      0      0      0
 C  05000     8475005595345             23      1      C     0      C      J     16     1     18      3      2      0      0      5      0
                          TOTAL      31257    466      C     C      0      0    335    11    952  27868   2437      0      0  30305   7472

 QUARTERLY                                   -----------PAST QUARTERS REP GEN/CDPA----------  ---PAST QTRS REPORTED IN USE MINUS SPECIAL ASC---
 ASSET DATA   STCCK NUMBER          RATE     --CURRENT-- ---PREV---- 3/8 4/8 5/8 6/8 7/8 8/8    CUR -PREV-    3/8    4/8   5/8   6/8   7/8   8/8
              14-28                 29-33    34-37 38-41 42-45 46-49                                 50-55

 C  01000     8475005458197         C.C03    0000--------   -------                           27861 023041 22010 19779 19775     9     2 19176
                                    .0170         C181        C089   53  67  51  35  27  19
```

COND

TI

Figure 3. D039 Format 50 printout.

```
SAALC DIV F IM AA ILS MSTR 8475005458197      REPORTED ASSETS/REQUIREMENTS DETAILS          FORMAT 100                        D039.PHIC
MCFCG - PAESAA        CGSN 8475005458197          FY  81/82-1  U   80 JUN 03                 AS OF 80 MAR 31                  PAGE     413
MMIIEAA  SEL MGT 0    BPAC 9400000200                                                            ANTI/G GARMENT.CUTA
REF 1-6 PAESAA  SECTION 1 PEACETIME AUTHORIZATION AND ASSET DATA
PART 2                                                              BASE NAME HILL AFB UT          DODAAD FE2027   AREA 1
SEC LINE ACT  STOCK NO     OWN ACCT  DIA     SERV    UNSERV  INTNS            ASSET            CONOM  R/M   ID DODAAD REASON CO
 7  8-12  13  14-28           29-30  31-36   37-42   43-48   49-54            TOTAL            55-58  59-62 65 66-71  73-78

 1  BAA** C   8475004802497    0A  000000  000000  000000  000000           000000           0002   0000  0    2027 LS

 1  BAB** C   8475005458197    0A       0       0       0       0                0              1   0000  0    2027 LS
              BASE TOTAL                0       0       0       0                0              3      0
PART 2                                                              BASE NAME KELLY AFB TX         DODAAD FE2059   AREA 1

 1  BCB** C   8475005458197    0A  006100  002432  000000  000000           008532           0000   0000  0    2059 HALAMS
              BASE TOTAL             6100    2432       0       0             8532              0      0
PART 2                                                              BASE NAME EDWARDS AFB CA       DODAAD FE2805   AREA 1

 1  BEA**     8475004802497    0A  000000  000000  000000  000000           000000           0001   0000  0    2805

 1  BEB**     8475005595345    0A       0       0       0       0                0              5   0000  0    2809
              BASE TOTAL                0       0       0       0                0              6      0
PART 2                                                              BASE NAME EGLIN AFB FL         DODAAD FE2823   AREA 1

 1  BFB** C   8475005458197    0A  000000  000000  000000  000000           000000           0007   0000  0    2823 LS
              BASE TOTAL                0       0       0       0                0              7      0
PART 2                                                              BASE NAME PATRICK AFB FL       DODAAD FE2829   AREA 1

 1  BGA**     8475005458197    0A  000000  000000  000000  000000           000000           0001   0000  0    2829
              BASE TOTAL                0       0       0       0                0              1      0
PART 1                                                              BASE NAME CHANUTE AFB IL       DODAAD FE3010   AREA 1
 REFERENCE    AUTH STOCK NO/ NOMENCLATURE OR R  ORGANIZATION         E  R  V  ALLOW    AUTH IN USE I  M     MPL                   ERROR OR
SEC LINE ACT  ASSET STOCK NO AUTH STOCK NO   F  NO  UKCL DET   SRAN  C  C  S  IDENT     OR REG NO  C  C     IND  ID MOS          REASON CO
 7  8-12  13  14-28                             29-40          41-44 45 46 47 45-54    55-58 59-62 63 64-65      66 67-73        74-79

 1  BHA**     8475005458197  ANTI/G GARMENT, 0  ABR922300000   3018           016A000  0013  0000  P  0J        0 ATC
 1  BHB**     8475004802463  8475005458197      ABR922300000   3018           016A000     0     1  S  0J        0 ATC

 1  BHC**     8475004802497  8475005458197      ABR922300000   3018           016A000     0     1  S  0J        0 ATC
 1  BHD**     8475005595342  8475005458197      ABR922300000   3018           016A000     0     3  S  0J        0 ATC

 1  BHE**     8475005595344  8475005458197      ABR922300000   3018           016A000     0     3  S  0J        0 ATC
 1  BHF**     8475005595345  8475005458197      ABR922300000   3018           016A000     0     3  S  0J        0 ATC

 1  BHG**     8475005595346  8475005458197      ABR922300000   3018           016A000     0     2  S  0J        0 ATC
                                                                    BASE TOTAL           13    13
```

Figure 4. D039 Format 100 printout.

SAALC DIV F IM AA ILS MSTR NSN 8475005458197 PROJECTED REQUIREMENTS/ASSETS SUMMARY FORMAT 250 RCS-LOG-MMR-Q-7176 D039.PH1A
REFCG - PAEMAA CGSN 8475009458197 FY 81/82-1 U A0 JUN 83 AS OF 80 MAR 31 PAGE 489
MMIIEAA SEL MGT B BPAC 4400008200 ANTI/G GARMENT,CUTA

QTR & FY --		REPORTED	4/80	4/81	1/82	2/82	BUY 3/82	4/82	2/83	BUD 4/83	4/84	4/85	4/86
RQMTS	AF INITIAL	0	0	0	0	0	0	0	0	0	0	0	0
	PCSP INITIAL	0	0	0	0	0	0	0	0	0	0	0	0
	ANG INITIAL	0	0	0	0	0	0	0	0	0	0	0	0
	AFR INITIAL	0	0	0	0	0	0	0	0	0	0	0	0
	AF ADDITIVE	25175	25175	25175	25175	25175	25175	25175	25175	25175	25175	25175	25175
	WRM	0	0	0	0	0	0	0	0	0	0	0	0
	MAP APPROVED	0	0	0	0	0	0	0	0	0	0	0	0
	REPLACEMENT	0	4163	9715	11103	12471	13879	15265	19428	20817	26369	31721	37493
	W/W TOTAL RQMTS	25175	29338	34,890	36278	37666	39053	40,440	44603	45992	51544	57096	62,648
ASSETS	IN USE	22207	22207	22207	22207	22207	22207	22207	22207	22207	22207	22207	22207
	IN PLACE	0	0	0	0	0	0	0	0	0	0	0	0
	WHSE SVC	2437	2437	2437	2437	2437	2437	2437	2437	2437	2437	2437	2437
	WHSE UNSVC	0	0	0	0	0	0	0	0	0	0	0	0
	FUNDED & O/O	7472	7472	7472	7472	7472	7472	7472	7472	7472	7472	7472	7472
	W/W TOTAL ASSETS	32116	32116	32116	32116	32116	32116	32116	32116	32116	32116	32116	32116
NET ACCUM RQMTS		0	0				6937			13876	19428	24,980	30,532

BUY/BUDGET & LATER RQMTS --		BUY	BUDGET	4TH QTR 4TH YR	4TH QTR 5TH YR	4TH QTR 6TH YR	4TH QTR 7TH YR
		6737	6737		5552	5552	5552
-----UNIT COST-----							
PRICE W/O FDT	143	991,971	1,346,166		1154816	1,226,772	1,277,168
STANDARD PRICE	147	1,019,739	1360044		1,188,129	1,265,856	1,338,032
INITIAL SPARES		0	0	0	0	0	0
TECH DATA		0	0	0	0	0	0
OTHER COSTS		0	0	0	0	0	0
TOTAL WITH FDT	$\boxed{147}$	1,019,739	1360044		1198,128	1,265,856	1,338,032

------ITEM INFO------ / ------BUY NET REQUIREMENTS------

AF INITIAL	0	AF ADDITIVE	0
PCSP INITIAL	0	WRM	0
ANG INITIAL	0	MAP APPROVED	0
AFR INITIAL	0	REPLACEMENT	11393
BACK ORDER QNTY		INITIAL SPARES FACTOR	.00
PRCMT LEAD/MOS.	$\boxed{10}$	PROCURABLE YES DATE	0120
REPL FACTOR	.2500	REPL CRIT CODE	(A)C
REPAIR LOCATION	DEPOT	BASE Y CONTR	OTHER
AUTH SUPPLY LVL	2242	DISPOSAL DEFFERRED	0
DIR/FLIC/HOLD-AF	389	DIR/FLIC/HOLD-MAP	0
TERMINATION LVL	58300	TERMINATION QNTY	0
RETENTION LVL	80575	RETENTION QNTY	0
EXCESS WAREHOUSE	0	EXCESS IN SERVICE	0
UNSUIT WAREHOUSE	0	UNSUIT IN SERVICE	0
UNSUIT ON ORDER	0	UNSUIT O/E HOLD	0
TOTAL ACQUIRED	31257	LOST FROM SYSTEM	952
COMP GROUP GAINS	0	COMP GROUP LOSSES	0
PREV COMP --BUY	18549	BUDGET	17676
TERM	0	EXCESS	0

UC

DPDT

-----MOS DATA AT BUY/BUDGET POSITION-----

MDS	GROSS RQMT	ASSETS IN SVC	ASSETS OTHER	NET RQMT
AF530	1929	1179	281	469
	2303	1179	281	843
ATC	21	13	2	6
	25	13	2	10
CONTRAD	2	1	0	1
	2	1	0	1
H412A	134	72	30	32
	160	72	30	58
412-	1050	637	159	255
	1253	637	159	458
412A	46043	25975	9430	10638
	54557	25979	9430	19144

-----COMMAND DATA AT BUY/BUDGET POSITION-----

COMD	GROSS RQMT	ASSETS IN SVC	ASSETS OTHER	NET RQMT
0F UNK	136	72	10	17
	160	72	10	54
0A AAC	357	213	57	87
	425	213	57	155
0C ADC	631	474	101	56
	928	474	101	353
0D AFE	6303	3735	978	1590
	7523	3735	979	2809
0F LOG	4173	1180	2523	470
	4547	1193	2523	846
0J ATC	6106	3502	1121	1483
	7293	3502	1121	2670
0M AFR	505	358	85	147
	677	358	85	225
0R PAF	1833	1154	310	369
	2309	1154	310	845
0S SAC	2249	1150	351	748
	2695	1150	351	547
0T TAC	12382	7626	2191	2565
	15497	7626	2191	5555
4Z ANG	13686	8202	2161	3323
	16344	8202	2161	5981

Figure 5. D039 Format 250 printout.

The condemnation percentage (COND) is determined by dividing the condemnation rate by the demand rate. For example, consider the following printout figures:

Repair rate = .05
Condemnation rate = .20

The demand rate (OIMD) equals .05 + .20 = .25, if no other interchangeable stock numbers are to be included. Therefore, the condemnation percentage (COND) = .20 ÷ .25 = 80%. If the repair rate equals zero, the condemnation percentage becomes 100%.

The input data used for the analysis of the anti-G suit is shown in Table 3. Much of the input is concerned with repair data (variables BMH, DMH, RMH, BMC, BRCT, DRCT), but such data were negligible for the anti-G suit. Unfortunately, we could not obtain the number of bases using the anti-G suit because this information involves the locations of certain planes. These locations were confidential, so we made a reasonable guess for the number of CONUS and overseas bases. Usually this information can be found in D039 Format 100 printout (Fig. 4). Due to these same circumstances, "average flight-hours per day" for applications using the suit was also nondeterminable, so again an estimate was made. All other information was in the format printouts.

Figure B-10 is the LCC output for the anti-G suit. The top half of the output is the echo of input data divided between the input unique to this item (left side) and the standard input for all items (right side). In the unique input data, the number for mean flight-hours between demands is calculated directly from the demand rate. Also in the same column, the number of bases is separated between CONUS and overseas.

The bottom half of the output report (Fig. B-10) is the cost analysis in terms of number and cost. For the anti-G suit, $3.26 million is necessary to initially supply the 60 bases with installed items. Each CONUS base requires two items in inventory for 99% security of not running out; each overseas base requires three items, with the extra item reflecting the greater time for resupply. The cost to initially stock all bases is $19,845. For the 99% security at depot level, 145 items need to be stocked (at a cost of $21,315).

Since no significant repairs are made on the anti-G suit, the annual maintenance cost is actually the cost associated with resupplying condemnations. With the demand rate used, 145 items will be condemned per year on the average. The cost of replacing the condemned items is $21,315 per year; and over a 10-year period, $213,150 (without discount or inflation). The total incremental LCC of using this item totals $3.52 million.

TABLE 3. ANTI-G SUIT (D039) INPUT

Variable	Location	Comment
ID = 2	--	Calendar-month-dependent used because demand rate is in terms of months
TI = 22,207	Fig. 3, TI	Represents average in use over most recent 4 quarters
LFT = 10	--	Estimate; actually, suits have no specific lifetime
MC = 45	--	Estimate
MO = 15	--	Estimate
PERCNT = 100.	--	Investigation at base level revealed no depot repairs
BMH = 0. DMH = 0. RMH = 0.	--	Investigation at base level, all times are negligible
OIMD = .0012	Fig. 3, COND	Repair rate = .000 COND rate = .017 Demand rate = $\frac{.017+.000}{12}$ $= .0012 \frac{\text{demands}}{\text{month}}$
UC = 147.	Fig. 5, UC	
SIGMA = .99	--	Estimated safe inventory coverage
BMC = 0.	--	Investigation showed insignificant repair costs
COND = 100.	--	Repair = .000, so demand rate is made up entirely of condemnations
BRCT = 0.	--	Investigation revealed negligible time loss if repair made
DMFH = 1.5	--	Estimate
DPDT = 300.	Fig. 5, DPDT	Time is given as 10 months on printout; multiply by 30 days/month
DRCT = 0.	--	Investigation showed no depot repairs

D062 Items

D062 items are unrecoverable. Once shipped from the depot, these items are no longer accounted for at depot level. This fact alone makes the assembling of input data for an LCC analysis difficult. However, a fairly accurate demand rate can be manually computed based on past demand from bases. This critical information, combined with good estimates for other data, can produce the desired cost analysis.

The input data required for an LCC analysis of a D062 item is the same as that for D039 and D041 items. As with D039 items, much of the input information for D062 items is not available on the standard printout. The missing data must be investigated, at the base or depot level for best information, or estimated. The standard printout for D062 items is titled "EOQ Computation Notice," in which three input variables can be found--OIMD (indirectly), DPDT, and UC. Many of the input variables concern repair, so barring the unusual occurrence of a D062 item requiring significant repair time and/or cost, these variables will reflect values for no repair.

Accountability of D062 items is minimal at depot level, so good estimates of total items in use and number of bases using the item can be difficult to get. The approach used in the analysis completed for this report was to find an accountable item whose end use is the same as the D062 item. Then we took the total in-use and base information for the accountable item and used these for the D062 item.

The D062 items analyzed in this report are an oxygen mask and oxygen connector. To obtain an estimate of the total number installed, we assumed that one mask and connector existed for every oxygen regulator, a D041 item for which an accurate estimate of number installed was available. Therefore, for in-use and base information, we matched the D062 items with the depot-accountable oxygen regulator.

Table 1 described how input data for D062 items in general may be obtained. Figure 6 gives the exact location of printed information on a sample EOQ Computation Notice.

The demand rate (OIMD) is determined by using the number from Monthly Rate-Demands (DMND) of the EOQ Computation Notice. One of the following two computation methods is used, based on whether the item is flight-hours or calendar-month dependent.

(1) OIMD, flight-hours dependent: Take DMFH (flight-hours per day per device) x 30 (days/month) x TI (total in use). Divide this number (flight-hours/month) by 100 and take the result to divide into DMND (Monthly Rate-Demands).

Example:

DMFH	=	2 flight-hours per day per item
Days per month	=	30
TI	=	2000 total items in use
DMND	=	50
2 X 30 x 2000	=	120,000 flight-hours per month
120,000 ÷ 100	=	1200
50 ÷ 1200	=	.042 demands per 100 unit flight-hours.

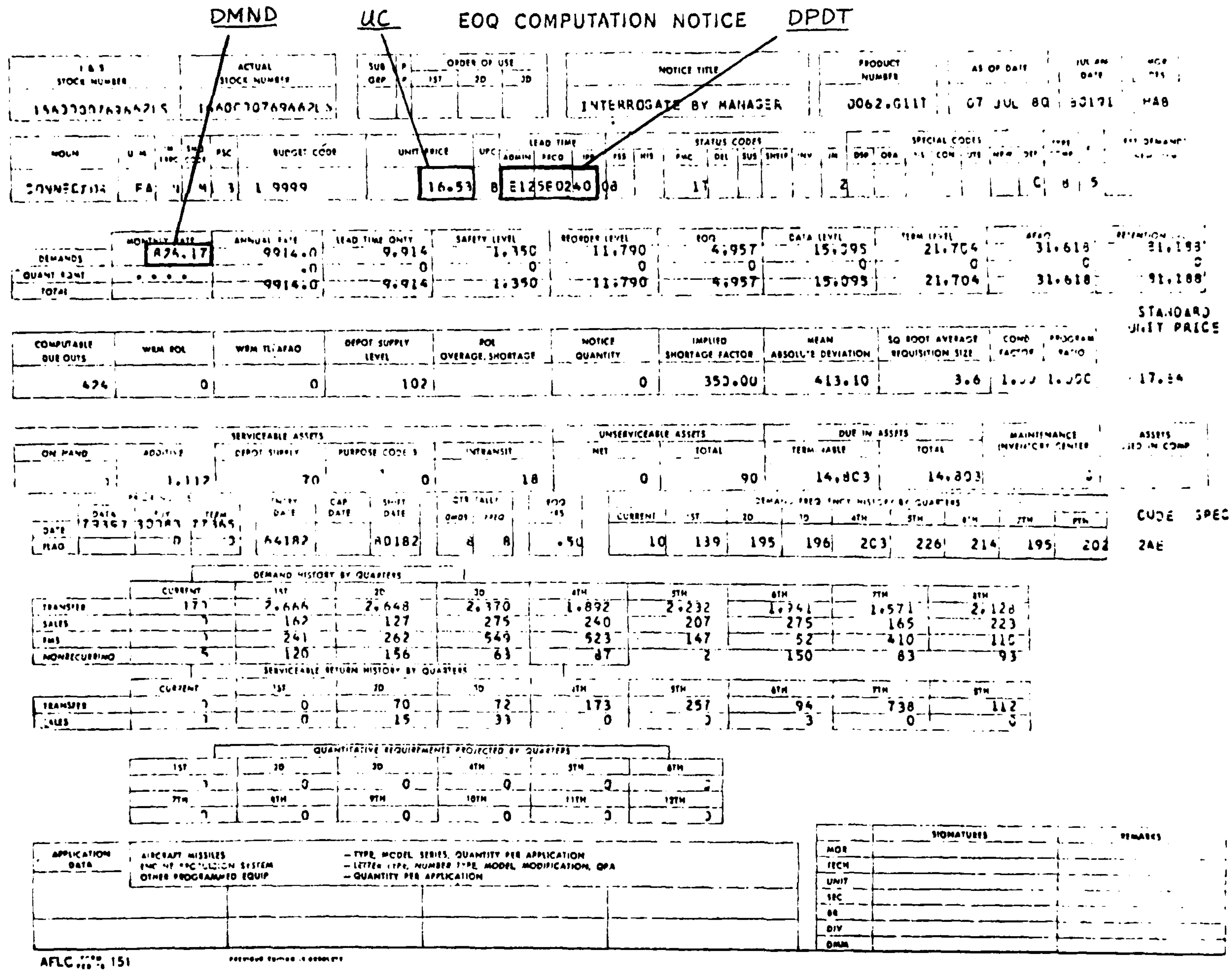


Figure 6. D062 EOQ Computation Notice printout.

(2) OIMD, calendar-month dependent: Take DMND (Monthly Rate-Demands) and divide by TI (total in use).

Example: TI = 2000
DMND = 50
50 ÷ 2000 = .025 demands per month per item

The input data used for the oxygen connector is shown in Table 4. Most of the input has had to be investigated or estimated, which should be avoided if possible. A search into data bases interfacing with D062 or associated with end-of-quarter (EOQ) times may provide some additional solid information.

The cost results of the LCC analysis for the oxygen connector are printed in Figure B-11. The top half of this output gives an echo of input data except for mean flight-hours between demands. This number is calculated directly from the demand-rate (OIMD) input. It indicates a total of 1351 flight-hours between any condemnation, on the average. The bottom half of this output gives the desired output information. Notice that the total initial cost of supplying the necessary base items is $413,250. The required base inventories, to be 99% sure of not running out, are 22 for CONUS and 44 for overseas bases. The associated combined cost for initial stocking is $27,275. For the 99% security at depot, 10,363 items need to be kept in stock, at a cost of $171,300.

For annual maintenance cost, the 10,128 so-called repairs are actually annual condemnations, because the input data reflected zero repairs. Therefore, with no repair costs, the only annual cost is the cost of replacing condemned items--$167,416 per year. This number is multiplied by 10 to obtain the lifetime (10 years) maintenance costs. Finally, the 10-year maintenance cost is added to the initial costs to give total incremental LCC--$2,285,983.

Figure B-12 contains the LCC-LSD output for the oxygen mask.

SENSITIVITY OF COST TO CHANGES IN RELIABILITY AND MAINTAINABILITY

The incremental LCC for the oxygen regulator is $43,495,544 (Fig. B-4); for the right-hand anti-G valve, $123,573 (Fig. B-7); and for the left-hand valve, $907,337 (Fig. B-1).

To reduce LCC, possibly by improving maintainability (reducing hours to repair), design changes could be considered. We conducted a sensitivity analysis to determine the dollar savings resulting from various assumed reductions in demand rate and repair hours. This, of course, would indicate how much money could be afforded for the design changes.

For the oxygen regulator the demand rate was set at 100%, 66.7%, and 50% of the input value; and for the anti-G valves, at 100%, 50%, and 33.3% of the input values. Most regulator repair work is done at depot level, so the DMH was set at 100%, 92%, 84%, 76%, and 68% of the input DMH value. The anti-G valves are usually repaired at base level, so the BMH was set at 100%, 92%, 84%, 76%, and 68% of the input BMH value. Incremental LCC was determined for all 15 combinations (3 demand rates X 5 man-hour values) for each item.

TABLE 4. OXYGEN CONNECTOR (D062) INPUT

Variable	Location	Comment
ID = 1	--	Equipment specialist recommendation
TI = 25,000	--	Matched total in-use values with oxygen regulator
LFT = 10	--	Estimate
MC = 45	--	Matched base number with that of oxygen regulator
MO = 15	--	Same explanation as for MC
PERCNT = 100.	--	No depot repairs for D062 items
BMH = 0. DMH = 0. RMH = 0.	--	Investigation at base level; all times are negligible
OIMD = .074	Fig. 6, DMND	See text for computation formula; DMFH = 1.5, TI = 25,000, DMND (monthly demand) = 826
UC = 16.53	Fig. 6, UC	
SIGMA = .99	--	Estimated safe inventory coverage
BMC = 0.	--	Investigation showed insignificant costs
COND = 100.	--	Demand is entirely caused by condemnations; negligible repair time if any
BRCT = 0.	--	Investigation revealed negligible repair time
DMFH = 1.5	--	Estimate
DPDT = 365.	Fig. 6, DPDT	Must add "Administration" + "Production" under Lead Time section
DRCT = 0.	--	No depot repairs

Figures B-5, B-8, and B-2 (using MTBD, the reciprocal of the demand rate) show the results for the regulator and right- and left-hand valves respectively. The results are plotted in Figures B-6, B-9, and B-3. The greatest reduction in total cost results from reducing the repair hours (over the ranges explored).

Almost all reductions occur in maintenance costs, with the number of installed devices remaining constant and the inventories being decreased only slightly.

Doubling the MTBD for the oxygen regulators shows a reduction of $16 million (36%). Tripling the MTBD for the right- and left-hand anti-G valves shows reductions of $49,000 (39%) and $534,000 (60%) respectively.

CONCLUSIONS

As a result of this study, we believe that the Logistic Support Cost Model of AFLC is too complex and has data requirements that are too vague for use with life support equipment. A model for costing the life cycle of life support devices (the LCC-LSD model) has been developed to use data obtained from the D041, D039, and D062 data bases to analyze changes in LCC due to changes in design and maintenance strategies. The LCC-LSD model calculates installed cost, initial inventory costs, and maintenance and replacement costs over the lifetime of the item to provide data for the analysis. An optional plot capability enables the user to rapidly assess the effect on LCC from reducing demand rates and repair times.

The ease and reliability of an analysis is related to the type of item studied. D041 items are the easiest to analyze and provide the most reliable results because of the detail provided in the D041 factor printout about an item and its repair history. D062 items are the most difficult to analyze and have the least reliable results because very little information is available on a D062 EOQ Computation Notice. A major problem is having to estimate the total numbers installed by matching a D062 item to an item that has a known number installed and the same end use. D039 items fall in the middle ground in both ease and reliability of analysis. Determining the number installed and number condemned from the Format 50 and Format 100 printouts is the major problem encountered in analyzing a D039 item.

For confirmation of the number installed or number condemned for D039 or D062 items, consulting an item manager or equipment specialist at a base or depot is very important.

The ease of estimating the number installed for a D041 item depends on the type of demand. For calendar-month-dependent items, the number installed is estimated very accurately by the monthly figure for past item-installed programs. For flight-hour-dependent items, estimating the number installed is difficult. If the number of each type of plane is known, then the number installed can be accurately estimated. Air Force personnel may be able to readily obtain this sensitive information.

We recognize that LCC is only one of a variety of considerations when establishing design specifications for life support equipment. For example, when justified by threat-to-life situations, reasonably high levels of reliability should be specified, along with a requirement that such reliability be demonstrated through tests. This adds to initial cost, but in addition to saving lives, it reduces annual maintenance costs. Items such as the oxygen regulator, with periodic overhaul required even though the item has not failed, should be reexamined. However, LCC analysis can identify areas where significant savings can be realized. Shelf-life is one area of potential savings which surfaced in our analysis. The short shelf-life for some items can possibly be corrected by using more durable materials, providing better sealing from environmental influence, and simplifying the design.

Finally, efforts to reduce LCC are often frustrated by the hard realities of meeting budgets and schedules. Managers are often reluctant to fund during a current year the extra development costs that will produce maintenance savings for other managers in future years. However, the U.S. Air Force could focus more attention on increased reliability in life support equipment and justify the added initial cost through LCC analysis. Reliability is attained during design, is strongly increased by simplicity of design and elimination of nonessential requirements, and is only specified in a meaningful manner when quantified and defined by test requirements.

RECOMMENDATION

The one outstanding problem still unsolved after this research is how to accurately determine the number of items installed for D039 (anti-G suit) and, especially, D062 (oxygen mask and connector) items. The LCC-LSD model computes many values based on total items installed; hence, the more accurate the input for number of items installed, the more accurate are the computed results. We recommend that a method be developed for finding the number of installed items. This can be done by finding the raw data base for the information sought. Throughout this research, we have found many data bases that collect a great variety of data; but for the most part these data were retained in raw form rather than in logical data bases of the kind needed for LCC analysis. The full potential of LCC analysis will be achieved only when the required data bases are formatted in accordance with the logic appropriate to LCC and become routinely available.

The theory of incremental life-cycle costing need not be restricted solely to life support equipment. The LCC-LSD model can be applied to any equipment where failure and repair activities contribute significantly to total life-cycle cost.

APPENDIX A. THREE PRIMARY EQUATIONS OF THE AFLC LOGISTICS SUPPORT COST MODEL

C_1 = Cost of FLU Spares

$$= M \sum_{i=1}^{N} (STK_i)(UC_i) + \sum_{i=1}^{N} \frac{(PFFH)(QPA_i)(UF_i)(1-RIP_i)(NRTS_i)(DRCT)}{MTBF_i} (UC_i)$$

$$+ \sum_{i=1}^{N} \frac{(TFFH)(QPA_i)(UF_i)(1-RIP_i)(COND_i)}{MTBF_i} (UC_i)$$

C_2 = On-Equipment Maintenance

$$= \sum_{i=1}^{N} \frac{(TFFH)(QPA_i)(UF_i)}{MTBF_i} [PAMH_i + (RIP_i)(IMH_i) + (1-RIP_i)(RMH_i)] (BLR)$$

$$+ \frac{TFFH}{SMI} (SMH)(BLR) + \frac{(TFFH)(EPA)}{CMRI} (ERMH)(BLR)$$

C_3 = Off-Equipment Maintenance

$$= \sum_{i=1}^{N} \frac{(TFFH)(QPA_i)(UF_i)(1-RIP_i)}{MTBF_i} \Big\{ (BCMH_i)(BLR)$$

$$+ RTS_i[(BMH_i)(BLR + BMR) + (BMC_i)(UC_i)]$$

$$+ NRTS_i[(DMH_i)(DLR + DMR) + (DMC_i)(UC_i)]$$

$$+ [2(NRTS_i) + COND_i][(PSC)(1-OS) + (PSO)(OS)](1.35\ W_i) \Big\}$$

$$+ \frac{(TFFH)(EPA)(1-ERTS)}{CMRI} (EOH)(EUC)$$

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APPENDIX B. LCC-LSD OUTPUTS, TABLES, AND PLOTS

```
INCREMENTAL LIFE-CYCLE COST OF ANTI-G VALVE, LEFT-HAND (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:                                          CONDITIONS:
     BASE LABOR HOURS TO REPAIR                     4.00
     DEPOT HOURS TO REPAIR                          4.00           REMOVAL IS FLIGHT-HOURS DEPENDENT.
     MEAN FLT. HRS. BETWEEN DEMANDS               207.73
     NO. OF ITEMS INSTALLED                       140         STANDARD DATA:
     NUMBER OF BASES    CONUS  -0    OVERSEAS      10
     UNIT COST IN DOLLARS                         600.00           BASE HOURLY LABOR RATE         $13.03
     PARTS MAINT. COST, PCT OF UNIT COST           19.00           DEPOT HOURLY LABOR RATE        $18.05
     BASE LABOR HOURS TO RMV/REPLACE                1.50           DAYS TRANSIT DELAY, BASE-DEPOT
     PERCENT OF CONDEMNATION                        2.00                CONUS                     $28.00
     PERCENT OF BASE REPAIR                        74.00                OVERSEAS                  $66.00
     DAYS REPAIR DELAY, DEPOT                      34.00
     DAYS REPAIR DELAY, BASE                        3.00
     FLIGHT-HOURS/DAY/DEVICE                        1.50
     DAYS PROCUREMENT DELAY, DEPOT                180.00
     ASSUMED YEARS LIFETIME                           10

           COST OF INSTALLED ITEMS                                                      $   84000.00

           INITIAL INVENTORY COST

                   EACH CONUS BASE             0 ITEMS
                   EACH OVERSEAS BASE          6 ITEMS

                TOTAL INITIAL INVENTORY COST FOR ALL BASES                              $   36000.00

                   DEPOT          34 ITEMS                                              $   20400.00

           ANNUAL MAINTENANCE COST FOR  368 REPAIRS

                   REMOVE/REPLACE LABOR       $      9963.60
                   REPAIR LABOR               $     21201.15
                   PARTS COST                 $     41112.96
                   CONDEMNATION COST          $      4416.00
                                              --------------

              TOTAL ANNUAL MAINTENANCE COST   $     76693.71          X 10 YEARS        $  766937.11
                                                                                        ------------
                                                       TOTAL INCREMENTAL LIFE-CYCLE COST $  907337.11
```

Figure B-1. LCC-LSD output for left-hand anti-G valve (D041 item).

TOTAL INCREMENTAL LIFE-CYCLE COST (CTOILC)
UNDER DIFFERENT BMH AND MTBD ARE:

BMH	MTBD (Flight-hours)	CTOILC
4.00	207.73	888137.11
3.68	207.73	876702.67
3.36	207.73	865268.22
3.04	207.73	853833.78
2.72	207.73	842399.34
4.00	415.45	490868.56
3.68	415.45	485151.33
3.36	415.45	479434.11
3.04	415.45	473716.89
2.72	415.45	467999.67
4.00	629.48	354172.26
3.68	629.48	350412.56
3.36	629.48	346652.87
3.04	629.48	342893.17
2.72	629.48	339133.48

Figure B-2. Output table of plot values (different BMH and MTBD) for left-hand anti-G valve.

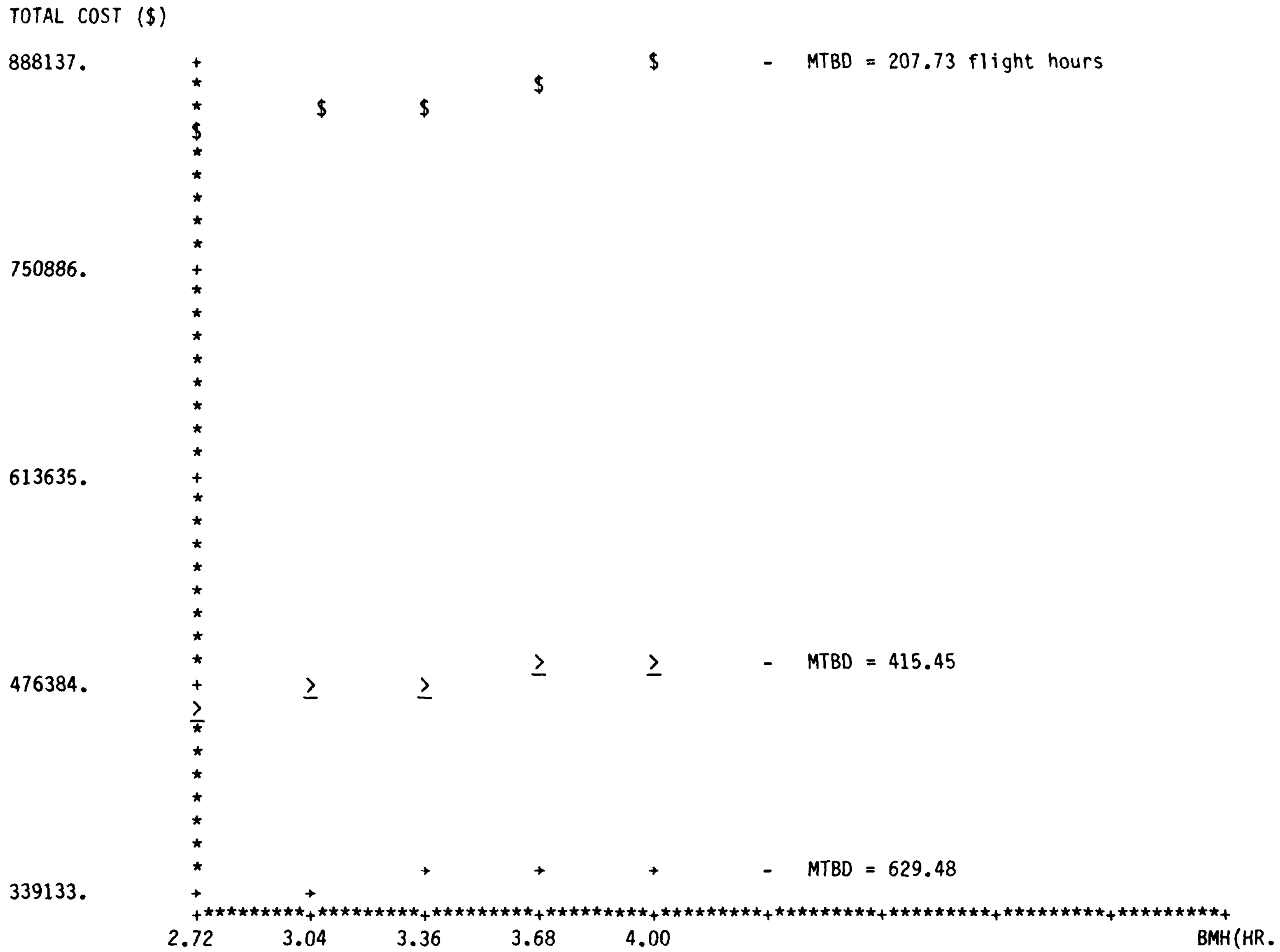


Figure B-3. Plot of life-cycle cost vs. BMH for three values of MTBD (Fig. B-2)--left-hand anti-G valve

```
INCREMENTAL LIFE-CYCLE COST OF OXYGEN REGULATOR (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:                                   CONDITIONS:
   BASE LABOR HOURS TO REPAIR                 6.00
   DEPOT HOURS TO REPAIR                      6.00        REMOVAL IS CALENDAR-MONTHS DEPENDENT.
   MEAN MONTHS BETWEEN DEMANDS               50.00
   NO. OF ITEMS INSTALLED                 25000        STANDARD DATA:
   NUMBER OF BASES   CONUS  56   OVERSEAS    14
   UNIT COST IN DOLLARS                     469.00        BASE HOURLY LABOR RATE           $13.03
   PARTS MAINT. COST, PCT OF UNIT COST       81.00        DEPOT HOURLY LABOR RATE          $18.05
   BASE LABOR HOURS TO RMV/REPLACE            1.50        DAYS TRANSIT DELAY, BASE-DEPOT
   PERCENT OF CONDEMNATION                    2.00           CONUS                         $28.00
   PERCENT OF BASE REPAIR                     7.00           OVERSEAS                      $66.00
   DAYS REPAIR DELAY, DEPOT                  37.00
   DAYS REPAIR DELAY, BASE                    4.00
   FLIGHT-HOURS/DAY/DEVICE                    1.50
   DAYS PROCUREMENT DELAY, DEPOT            180.00
   ASSUMED YEARS LIFETIME                       10

      COST OF INSTALLED ITEMS                                                     $ 11725000.00

      INITIAL INVENTORY COST

         EACH CONUS BASE            13 ITEMS
         EACH OVERSEAS BASE         24 ITEMS

        TOTAL INITIAL INVENTORY COST FOR ALL BASES                                $    499016.00

         DEPOT        800 ITEMS                                                   $    375200.00

      ANNUAL MAINTENANCE COST FOR  6000 REPAIRS

         REMOVE/REPLACE LABOR        $     162450.00
         REPAIR LABOR                $     637149.60
         PARTS COST                  $    2233753.20
         CONDEMNATION COST           $      56280.00
                                     --------------

        TOTAL ANNUAL MAINTENANCE COST $   3089632.80       X 10 YEARS              $ 30896328.0
                                                                                   ------------
                                                TOTAL INCREMENTAL LIFE-CYCLE COST  $ 43495544.0
```

Figure B-4. LCC-LSD output of oxygen regulator (D041 item).

DMH	MTBD (Months)	CTOILC
6.00	50.00	43495544.00
5.52	50.00	43012092.80
5.04	50.00	42528641.60
4.56	50.00	42045190.40
4.08	50.00	41561739.20
6.00	74.96	32968345.78
5.52	74.96	32645883.83
5.04	74.96	32323421.88
4.56	74.96	32000959.92
4.08	74.96	31678497.97
6.00	100.00	27668897.00
5.52	100.00	27427171.40
5.04	100.00	27185445.80
4.56	100.00	26943720.20
4.08	100.00	26701994.60

Figure B-5. Output table of plot values (different DMH and MTBD) for oxygen regulator.

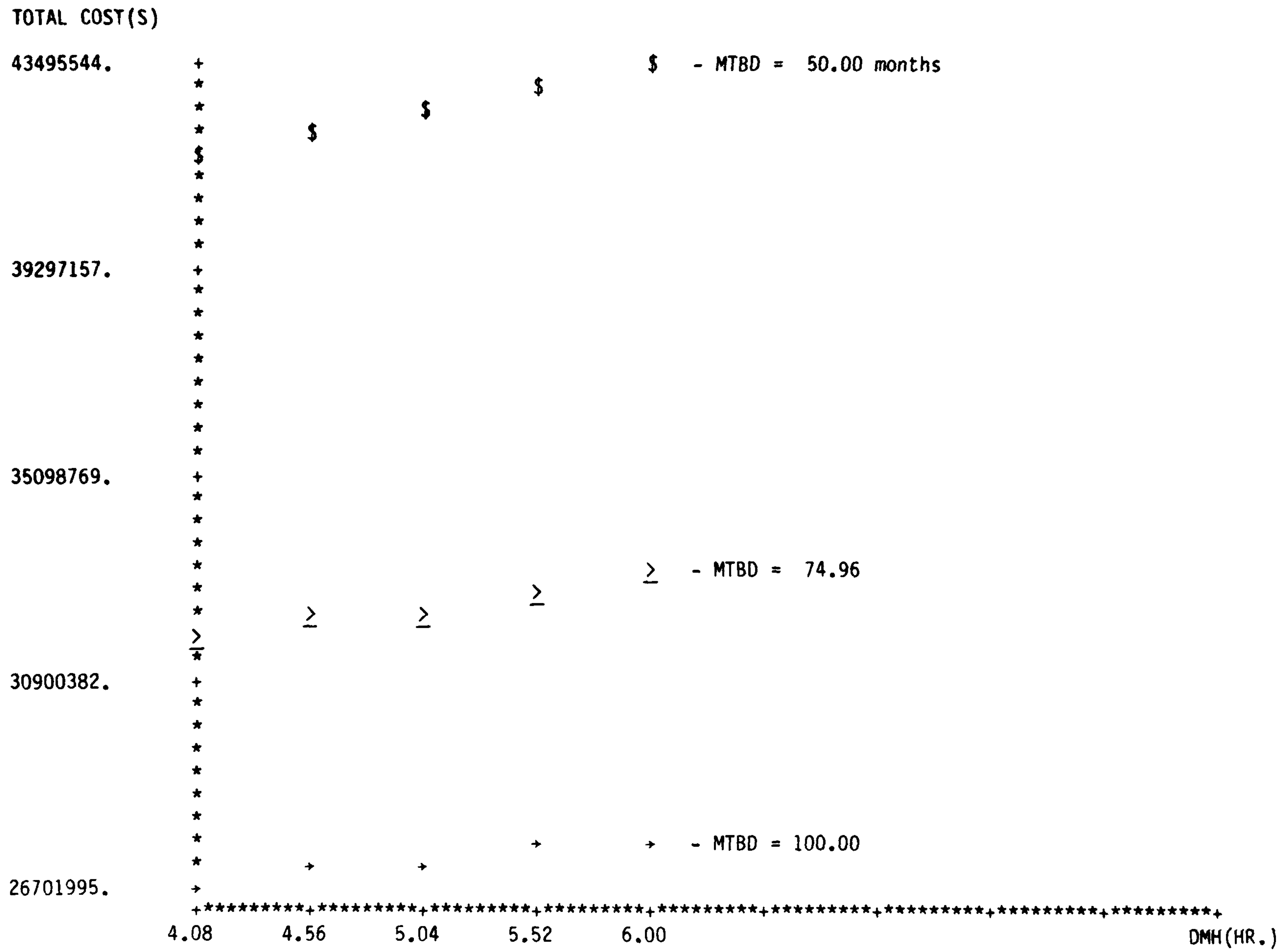


Figure B-6. Plot of life-cycle cost vs. DMH for three values of MTBD (Fig. B-5)--oxygen regulator.

```
INCREMENTAL LIFE-CYCLE COST OF ANTI-G VALVE, RIGHT-HAND (JUNE 1980 DATA) WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:                                    CONDITIONS:
     BASE LABOR HOURS TO REPAIR              4.00
     DEPOT HOURS TO REPAIR                   4.00            REMOVAL IS FLIGHT-HOURS DEPENDENT.
     MEAN FLT. HRS. BETWEEN DEMANDS       2012.07
     NO. OF ITEMS INSTALLED                140          STANDARD DATA:
     NUMBER OF BASES    CONUS   3    OVERSEAS   2
     UNIT COST IN DOLLARS                  360.50            BASE HOURLY LABOR RATE                $13.03
     PARTS MAINT. COST, PCT OF UNIT COST    26.00            DEPOT HOURLY LABOR RATE               $18.05
     BASE LABOR HOURS TO RMV/REPLACE         1.50            DAYS TRANSIT DELAY, BASE-DEPOT
     PERCENT OF CONDEMNATION                    0                 CONUS                            $28.00
     PERCENT OF BASE REPAIR                 74.00                 OVERSEAS                         $66.00
     DAYS REPAIR DELAY, DEPOT               37.00
     DAYS REPAIR DELAY, BASE                 4.00
     FLIGHT-HOURS/DAY/DEVICE                 1.50
     DAYS PROCUREMENT DELAY, DEPOT         180.00
     ASSUMED YEARS LIFETIME                    10

           COST OF INSTALLED ITEMS                                                      $    50470.00

           INITIAL INVENTORY COST

                  EACH CONUS BASE                     2 ITEMS
                  EACH OVERSEAS BASE                  2 ITEMS

                TOTAL INITIAL INVENTORY COST FOR ALL BASES                              $     3605.00

                  DEPOT         5 ITEMS                                                 $     1802.50

            ANNUAL MAINTENANCE COST FOR  38 REPAIRS

                   REMOVE/REPLACE LABOR               $       1028.85
                   REPAIR LABOR                       $       2178.95
                   PARTS COST                         $       3561.74
                   CONDEMNATION COST                  $             0
                                                      --------------

                TOTAL ANNUAL MAINTENANCE COST         $       6769.54      X 10 YEARS   $    67695.40
                                                                                        ------------
                                                        TOTAL INCREMENTAL LIFE-CYCLE COST $  123572.90
```

Figure B-7. LCC-LSD output for right-hand anti-G valve (D041 item).

BMH	MTBD (Flight-hours)	CTOILC
4.00	2012.07	123572.90
3.68	2012.07	122400.41
3.36	2012.07	121227.92
3.04	2012.07	120055.43
2.72	2012.07	118882.94
4.00	4024.14	87922.70
3.68	4024.14	87336.46
3.36	4024.14	86750.21
3.04	4024.14	86163.96
2.72	4024.14	85577.72
4.00	6042.26	74731.50
3.68	6042.26	74361.24
3.36	6042.26	73990.98
3.04	6042.26	73620.71
2.72	6042.26	73250.45

Figure B-8. Output table of plot values (different BMH and MTBD) for right-hand anti-G valve.

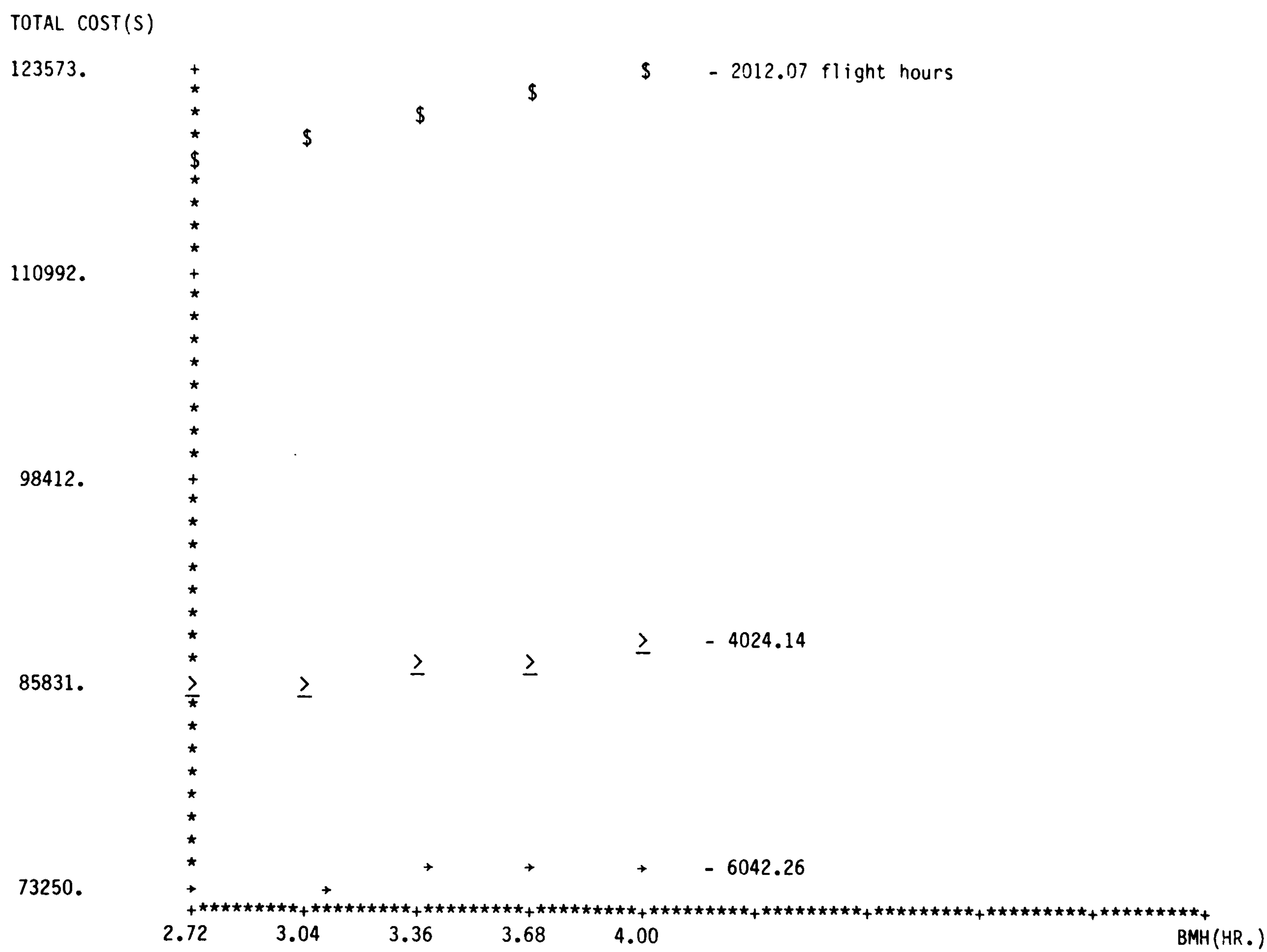


Figure B-9. Plot of life-cycle cost vs. BMH for three values of MTBD (Fig. B-8)--right-hand anti-G valve.

INCREMENTAL LIFE-CYCLE COST OF ANTI-G SUIT WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:	
BASE LABOR HOURS TO REPAIR	0
DEPOT HOURS TO REPAIR	0
MEAN FLT-HRS. BETWEEN DEMANDS	83333.33
NO. OF ITEMS INSTALLED	22207
NUMBER OF BASES CONUS 45 OVERSEAS	15
UNIT COST IN DOLLARS	147.00
PARTS MAINT. COST, PCT OF UNIT COST	0
BASE LABOR HOURS TO RMV/REPLACE	0
PERCENT OF CONDEMNATION	100.00
PERCENT OF BASE REPAIR	100.00
DAYS REPAIR DELAY, DEPOT	0
DAYS REPAIR DELAY, BASE	0
FLIGHT-HOURS/DAY/DEVICE	1.50
DAYS PROCUREMENT DELAY, DEPOT	300.00
ASSUMED YEARS LIFETIME	10

CONDITIONS:

REMOVAL IS FLIGHT-HOURS DEPENDENT.

STANDARD DATA:	
BASE HOURLY LABOR RATE	$13.0
DEPOT HOURLY LABOR RATE	$18.0
DAYS TRANSIT DELAY, BASE-DEPOT	
CONUS	$28.0
OVERSEAS	$66.0

COST OF INSTALLED ITEMS				$ 3264429.0
INITIAL INVENTORY COST				
EACH CONUS BASE		2 ITEMS		
EACH OVERSEAS BASE		3 ITEMS		
TOTAL INITIAL INVENTORY COST FOR ALL BASES				$ 19845.0
DEPOT 145 ITEMS				$ 21315.0
ANNUAL MAINTENANCE COST FOR 145 REPAIRS				
REMOVE/REPLACE LABOR	$ 0			
REPAIR LABOR	$ 0			
PARTS COST	$ 0			
CONDEMNATION COST	$ 21315.00			
TOTAL ANNUAL MAINTENANCE COST	$ 21315.00		X 10 YEARS	$ 213150.0
		TOTAL INCREMENTAL LIFE-CYCLE COST		$ 3518739.0

Figure B-10. LCC-LSD output of anti-G suit (D039 item).

```
            INCREMENTAL LIFE-CYCLE COST OF OXYGEN CONNECTOR WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:                                        CONDITIONS:
     BASE LABOR HOURS TO REPAIR                      0
     DEPOT HOURS TO REPAIR                           0           REMOVAL IS FLIGHT-HOURS DEPENDENT.
     MEAN FLT. HRS. BETWEEN DEMANDS            1351.35
     NO. OF ITEMS INSTALLED                  25000          STANDARD DATA:
     NUMBER OF BASES    CONUS  45    OVERSEAS       15
     UNIT COST IN DOLLARS                        16.53           BASE HOURLY LABOR RATE            $13.03
     PARTS MAINT. COST, PCT OF UNIT COST             0           DEPOT HOURLY LABOR RATE           $18.05
     BASE LABOR HOURS TO RMV/REPLACE                 0           DAYS TRANSIT DELAY, BASE-DEPOT
     PERCENT OF CONDEMNATION                    100.00                CONUS                        $28.00
     PERCENT OF BASE REPAIR                     100.00                OVERSEAS                     $66.00
     DAYS REPAIR DELAY, DEPOT                        0
     DAYS REPAIR DELAY, BASE                         0
     FLIGHT-HOURS/DAY/ITEM                        1.50
     DAYS PROCUREMENT DELAY, DEPOT              365.00
     ASSUMED YEARS LIFETIME                         10

           COST OF INSTALLED ITEMS                                                       $   413250.00

           INITIAL INVENTORY COST

                EACH CONUS BASE                           22 ITEMS
                EACH OVERSEAS BASE                        44 ITEMS

              TOTAL INITIAL INVENTORY COST FOR ALL BASES                                 $    27274.50

                DEPOT      10363 ITEMS                                                   $   171300.39

           ANNUAL MAINTENANCE COST FOR  10128 REPAIRS

                REMOVE/REPLACE LABOR         $            0
                REPAIR LABOR                 $            0
                PARTS COST                   $            0
                CONDEMNATION COST            $    167415.84
                                             --------------

              TOTAL ANNUAL MAINTENANCE COST  $    167415.84     X 10 YEARS               $  1674158.40
                                                                                         -------------
                                                   TOTAL INCREMENTAL LIFE-CYCLE COST     $  2285983.29
```

Figure B-11. LCC-LSD output for oxygen connector (D062 item).

```
INCREMENTAL LIFE-CYCLE COST OF OXYGEN MASK WITHOUT PRESENT-WORTH ANALYSIS

DATA UNIQUE TO ITEM:                                          CONDITIONS:
     BASE LABOR HOURS TO REPAIR                     0
     DEPOT HOURS TO REPAIR                          0              REMOVAL IS FLIGHT-HOURS DEPENDENT.
     MEAN FLT. HRS. BETWEEN DEMANDS           5882.35
     NO. OF ITEMS INSTALLED                  25000                STANDARD DATA:
     NUMBER OF BASES    CONUS  50    OVERSEAS    20
     UNIT COST IN DOLLARS                       31.69                 BASE HOURLY LABOR RATE           $13.03
     PARTS MAINT. COST, PCT OF UNIT COST            0                 DEPOT HOURLY LABOR RATE          $18.05
     BASE LABOR HOURS TO RMV/REPLACE                0                 DAYS TRANSIT DELAY, BASE-DEPOT
     PERCENT OF CONDEMNATION                   100.00                      CONUS                       $28.00
     PERCENT OF BASE REPAIR                    100.00                      OVERSEAS                    $66.00
     DAYS REPAIR DELAY, DEPOT                       0
     DAYS REPAIR DELAY, BASE                        0
     FLIGHT-HOURS/DAY/ITEM                       1.50
     DAYS PROCUREMENT DELAY, DEPOT             296.00
     ASSUMED YEARS LIFETIME                        10

           COST OF INSTALLED ITEMS                                                        $    792250.00

           INITIAL INVENTORY COST

                EACH CONUS BASE                            7 ITEMS
                EACH OVERSEAS BASE                        12 ITEMS

              TOTAL INITIAL INVENTORY COST FOR ALL BASES                                  $     18697.10

                DEPOT      1988  ITEMS                                                    $     62999.72

           ANNUAL MAINTENANCE COST FOR  2326 REPAIRS

                REMOVE/REPLACE LABOR          $           0
                REPAIR LABOR                  $           0
                PARTS COST                    $           0
                CONDEMNATION COST             $    73710.94
                                              --------------

              TOTAL ANNUAL MAINTENANCE COST   $    73710.94      X 10 YEARS               $    737109.40
                                                                                          -------------
                                                   TOTAL INCREMENTAL LIFE-CYCLE COST      $   1611056.22
```

Figure B-12. LCC-LSD output for oxygen mask (D062 item).

APPENDIX C

LCC-LSD COMPUTER PROGRAM LISTING

```
UNIVERSITY OF MINNESOTA FORTRAN COMPILER (VERSION 5.3 - 10/27/78) ON PURDUE DUAL 6500 MACE SYSTEM  10/31/80 AT 02.49

                   MNF.

                   C*****INCREMENTAL LIFE CYCLE COST MODEL FOR LIFE SUPPORT DEVICES*****
                   C*****************PURDUE UNIVERSITY 1979********************
         000000B         PROGRAM LCC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
         002051B         COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
         002051B         COMMON/UCOM2/LFT,CTOMAN,CANUMA
         002051B         COMMON/UCOM3/ID,NSEL,X(10),V(10),Y(30),NPRNT,IC,NINPU
         002051B         INTEGER STKD,TI,FREQCY,STKBU,STKBO
         002051B         REAL LAMDBU,LAMDBO,LAMDAD,MTBD,IFR,INT,IC(3),C(3)
                   C
                   C
                   C*********************************************************************
                   C*********************************************************************
                   C**                                                                 **
                   C**                                                                 **
                   C** VARIABLES LIST :                                                **
                   C**                                                                 **
                   C**     ID=1  INDICATES THAT DEVICE REMOVAL IS FLIGHT HOURS         **
                   C**                     DEPENDENT.                                  **
                   C**     ID=2  INDICATES THAT DEVICE REMOVAL IS CALENDAR MONTHS      **
                   C**                     DEPENDENT.                                  **
                   C**                                                                 **
                   C**     INTANA=1   NO PRESENT WORTH ANALYSIS                        **
                   C**                                                                 **
                   C**     INTANA=2   PRESENT WORTH ANALYSIS, NO INFLATION ANALYSIS    **
                   C**                                                                 **
                   C**     INTANA=3   PRESENT WORTH ANALYSIS WITH INFLATION            **
                   C**                                                                 **
                   C**     BCONDO =AVERAGE DEMAND PER OVERSEA BASE DUE TO CONDEMNATION **
                   C**     BCONDU =AVERAGE DEMAND PER U.S. BASE DUE TO CONDEMNATION    **
                   C**     BLR(S) =BASE LABOR RATE PER HOUR.                           **
                   C**     BMCC   =COST OF REPAIR PARTS OR KITS, AS A FRACTION OF UC.  **
                   C**     BMH    =HOURS TO REPAIR AT BASE.                            **
                   C**     BRCT   =BASE REPAIR DELAY, IN DAYS.                         **
                   C**     BRPB   =AVERAGE DEMAND FOR BASE REPAIR AT A BASE            **
                   C**     BRPDO  =AVERAGE DEMAND FOR DEPOT REPAIR AT AN OVERSEA BASE  **
                   C**     BRPDU  =AVERAGE DEMAND FOR DEPOT REPAIR AT A U.S. BASE      **
                   C**     BSDT(S)=BASE-DEPOT TRANSIT DELAY, IN DAYS.                  **
                   C**     BSDT(S)=BASE-DEPOT TRANSIT DELAY (U.S.) IN DAYS             **
                   C**     CANUMA =COST OF ANNUAL MAINTENANCE.                         **
                   C**     CCONDM =COST OF DEVICES CONDEMNED.                          **
                   C**     CPARTS =COST OF THE PARTS FOR REPAIR.                       **
                   C**     CONDC  =FRACTION OF DEVICES TO BE CONDEMNED.                **
                   C**     CRANDR =COST OF REMOVE AND REPLACE LABOR.                   **
```

```
C**     CREPAR =COST OF REPAIR LABOR.                                        **
C**     CTALLD =COST OF INSTALLED DEVICES.                                   **
C**     CTOILC =TOTAL INCREMENTAL LIFE CYCLE COST.                           **
C**     CTOMAN =TOTAL MAINTENANCE COST, OVER ALL LIFETIME.                   **
C**     DCOND  =AVERAGE DEMAND PER DEPOT DUE TO CONDEMNATION                 **
C**     DLR(S) =DEPOT LABOR RATE PER HOUR.                                   **
C**     DMFH   =FLIGHT HOURS PER DAY PER DEVICE.                             **
C**     DMH    =HOURS TO REPAIR AT DEPOT.                                    **
C**     DPDT   =DEPOT PROCUREMENT DELAY, IN DAYS.                            **
C**     DRCT   =DEPOT REPAIR DELAY, IN DAYS.                                 **
C**     DRPD   =AVERAGE DEMAND FOR DEPOT REPAIR AT A DEPOT                   **
C**     FREQCY =INTEGER PART OF PP                                           **
C**     IFR    =ANNUAL INFLATION RATE                                        **
C**     INT    =ANNUAL INTEREST RATE                                         **
C**     LFT    =ASSUMED LIFETIME, IN YEARS.                                  **
C**     LAMDBU,LAMDBO =AVERAGE DEMAND PER BASE.                              **
C**     LAMDAD =AVERAGE DEMAND AT DEPOT.                                     **
C**     MC     =NUMBER OF U.S. BASES USING DEVICE                            **
C**     MO     =NUMBER OF OVERSEA BASES USING DEVICE                         **
C**     MTBD   =MEAN TIME BETWWEEN DEMANDS.                                  **
C**     OBSDT(S)=BASE-DEPOT TRANSIT DELAY (OVERSEA) IN DAYS                  **
C**     OIMD   =DEMAND RATE FOR ITEM                                         **
C**     PERCNT =PERCENT OF DEVICE REPAIRS THAT CAN BE DONE AT BASE           **
C**     PP     =REPAIRS PER YEAR                                             **
C**     RMH    =HOURS TO REMOVE AND REPLACE AT BASE.                         **
C**     SIGMA  =CONFIDENCE COEFFICIENT OF INVENTORIES.                       **
C**     STKBO  =INITIAL INVENTORIES NEEDED PER OVERSEA BASE                  **
C**     STKBU  =INITIAL INVENTORIES NEEDED PER U.S. BASE                     **
C**     STKD   =INITIAL INVENTORIES NEEDED AT DEPOT.                         **
C**     TI     =TOTAL NUMBER OF DEVICES                                      **
C**     UC     =UNIT COST OF DEVICE.                                         **
C**                                                                          **
C**     S IN PARENTHESIS MEANS STANDARD DATA.                                **
C**                                                                          **
C**                                                                          **
C****************************************************************************
C****************************************************************************
C
C*****INPUT DATA
C
      NCRDR=5
      NPRNT=6
      BLR=13.03
      BSDT=28.0
      DLR=18.05
      OBSDT=66.0
```

```
      C(1)=1.0
      NINPU=0
C
      READ(NCRDR,3)NPLOT
   50 READ(NCRDR,26,END=1400)(NAME(I),I=1,80)
      CALL TITLE
C
      NINPU=NINPU+1
      READ(NCRDR,4)NM,(C(JJ),JJ=2,NM)
      READ(NCRDR,27)NH,PNT,NSEL
C
      IF(NPLOT.EQ.1) GO TO 100
      NM=1
      NH=1
C
 100  READ(NCRDR,32)INTANA,INT,IFR
      IF(INTANA.EQ.1)GO TO 150
      IF(INTANA.EQ.2)GO TO 200
      WRITE(NPRNT,33)INT,IFR
      GO TO 250
  150 WRITE(NPRNT,34)
      GO TO 250
  200 WRITE(NPRNT,35)INT
C
  250 READ(NCRDR,1)ID,TI,LFT,MC,MD,PERCNT
      READ(NCRDR,2)BMH,DMH,RMH,OIMD,UC,SIGMA,BMC,COND
      READ(NCRDR,2)BRCT,DMFH,DPDT,DRCT
C
      NN=0
      DO 1200 K=1,NM
      DO 1150 J=1,NH
      NN=NN+1
      IF(NN.EQ.1) WRITE(NPRNT,5)
C
      JJ=NH+1-J
      IF(NSEL.EQ.2) GO TO 300
         X(JJ)=BMH*(1.0-PNT*(J-1))
      GO TO 350
  300    X(JJ)=DMH*(1.0-PNT*(J-1))
  350 IF(NN.EQ.1)WRITE(NPRNT,6)BMH,DMH
C
C*****CALCULATE MTBD, FLIGHT HOUR DEPENDENT
C
      IF(ID.EQ.2) GO TO 400
         MTBD=100.0/OIMD
         IC(K)=MTBD/C(K)
         PP=DMFH*TI*365.00/IC(K)
         IF(NN.EQ.1) WRITE(NPRNT,8)IC(K)
      GO TO 450
```

```
C
C*****CALCULATE MTBD, CALENDAR MONTH DEPENDENT
C
  400    MTBD=1.0/OIMD
         IC(K)=MTBD/C(K)
         PP=12.0*TI/IC(K)
         IF(NN.EQ.1) WRITE(NPRNT,9)IC(K)
C
C***** ECHO OF INPUT DATA
C
  450 IF(NN.GT.1) GO TO 500
         WRITE(NPRNT,10)TI
         WRITE(NPRNT,11)MC,MO
         WRITE(NPRNT,12)UC
         WRITE(NPRNT,13)BMC
         WRITE(NPRNT,14)RMH
         WRITE(NPRNT,15)COND,BSDT
         WRITE(NPRNT,16)PERCNT,OBSDT
         WRITE(NPRNT,17)DRCT
         WRITE(NPRNT,18)BRCT
         WRITE(NPRNT,19)DMFH
         WRITE(NPRNT,20)DPDT,LFT
C
C***** CALCULATE DECIMAL EQUIVALENTS OF INPUT PERCENTS
C
  500 BMCC=BMC/100.0
      CONDC=COND/100.0
      PERC=PERCNT/100.0
C
C***** CALCULATE FRACTION OF U.S. AND OVERSEAS BASES
C
      M=MC+MO
      POSB=FLOAT(MO)/FLOAT(M)
C
C***** CALCULATE INTERNAL VARIABLE FOR (TI/M)
C
      TIB=TI/M
C
C***** DETERMINE DEMAND TYPE, IC( ) IS MTBD
C
      GO TO (550,600),ID
C
C*****DEVICE REMOVAL IS FLIGHT HOURS DEPENDENT.
C
  550 BCONDU=DMFH*BSDT*TIB*CONDC/IC(K)
C
      BRPDU=DMFH*BSDT*TIB*(1.0-PERC)*(1.0-CONDC)/IC(K)
C
```

```
      BCONDO=DMFH*OBSDT*TIB*CONDC/IC(K)
C
      BRPDO=DMFH*OBSDT*TIB*(1.0-PERC)*(1.0-CONDC)/IC(K)
C
      BRPB=DMFH*BRCT*TIB*PERC/IC(K)
C
      DCOND=DMFH*DPDT*TI*CONDC/IC(K)
C
      DRPD=DMFH*(DRCT+POSB*38.0)*TI*(1.0-PERC)*(1.0-CONDC)/IC(K)
C
      GO TO 650
C
C*****DEVICE REMOVAL IS CALENDAR MONTHS DEPENDENT.
C
  600 BCONDU=BSDT*TIB*CONDC/(30.0*IC(K))
C
      BRPDU=BSDT*TIB*(1.0-PERC)*(1.0-CONDC)/(30.0*IC(K))
C
      BCONDO=OBSDT*TIB*CONDC/(30.0*IC(K))
C
      BRPDO=OBSDT*TIB*(1.0-PERC)*(1.0-CONDC)/(30.0*IC(K))
C
      BRPB=BRCT*TIB*PERC/(IC(K)*30.0)
C
      DCOND=DPDT*TI*CONDC/(IC(K)*30.0)
C
      DRPD=(DRCT+POSB*38.0)*TI*(1.0-PERC)*(1.0-CONDC)/(IC(K)*30.0)
C
C***** SUM AVERAGE UNITS NEEDED IN U.S. BASE INVENTORY
C
  650 LAMDBU = BCONDU + BRPDU + BRPB
C
C***** SUM AVERAGE UNITS NEEDED IN OVERSEAS BASE INVENTORY
C
      LAMDBO = BCONDO + BRPDO + BRPB
C
C***** SUM AVERAGE UNITS NEEDED IN DEPOT INVENTORY
C
      LAMDAD = DCOND + DRPD
C
C
```

```
C*****NUMBER OF INITIAL INVENTORIES NEEDED PER BASE AND DEPOT.
C
      IF(LAMDBU.LT.50.0)GO TO 660
             SIGBU=SQRT(LAMDBU)
             STKBU=LAMDBU+2.33*SIGBU
      GO TO 665
  660 STKBU=NPSSN(LAMDBU,SIGMA,TI)
C
  665 IF(LAMDBO.LT.50.0)GO TO 670
             SIGBO=SQRT(LAMDBO)
             STKBO=LAMDBO+2.33*SIGBO
      GO TO 675
  670 STKBO=NPSSN(LAMDBO,SIGMA,TI)
C
  675 IF(LAMDAD.LT.50.0) GO TO 700
         SIGMAD=SQRT(LAMDAD)
         STKD=LAMDAD+2.33*SIGMAD
      GO TO 750
  700    STKD=NPSSN(LAMDAD,SIGMA,TI)
C
C*****COST OF INSTALLED DEVICES.
C
  750 CTALLD=TI*UC
C
C*****COST OF INITIAL INVENTORIES FOR ALL BASES.
C
      CINIBS=((STKBU*MC)+(STKBO*MO))*UC
C
C*****COST OF INITIAL INVENTORIES AT DEPOT.
C
      CINIDP=STKD*UC
C
C*******COST OF MAINTENANCE.
C
      FREQCY=IFIX(PP)
C
C***** INTERNAL PLOT CALCULATIONS AND BASE AND
C***** DEPOT LABOR COST CALCULATIONS.
C
      IF(NSEL.EQ.2) GO TO 800
         CREPAR=FREQCY*((BLR*X(JJ)*(CONDC+(1-CONDC)*(PERC)))+(DLR*DMH
     1*(1.0-PERC)))
      GO TO 850
  800    CREPAR=FREQCY*((DLR*X(JJ)*(1.0-PERC))+(BLR*BMH*PERC))
C
C***** CALCULATE REMOVE AND REPLACE COST
C
  850 CRANDR=FREQCY*RMH*DLR
```

```
C
C***** CALCULATE COST OF REPAIR KITS OR PARTS
C
      CPARTS=FREQCY*RMCC*UC*(1.0-CONDC)
C
C***** CALCULATE COST OF NEW REPLACEMENT EQUIPMENT
C
      CCONDM=FREQCY*CONDC*UC
C
C***** SUM COMPONENTS OF ANNUAL MAINTENANCE COST
C
      CANUMA=CRANDR+CREPAR+CCONDM+CPARTS
C
C**********CHECK FOR PRESENT WORTH ANALYSIS
C
      IF(INTANA.EQ.1)GO TO 900
      CALL INTRST
      GO TO 950
  900 CTOMAN=CANUMA*LFT
C
C**********CALCULATE THE TOTAL INCREMENTAL LIFE CYCLE COST.
C
  950 CTOILC=CTALLD+CINIBS+CINIDP+CTOMAN
C
C*****OUTPUT DATA
C
      IF(MC.EQ.0) STKBU = 0
      IF(MO.EQ.0) STKBO = 0
      IF(NN.GT.1) GO TO 1100
         WRITE(NPRNT,21)CTALLD,STKBU,STKBO,CINIBS,STKD,CINIDP,FREQCY
         WRITE(NPRNT,22)CRANDR,CREPAR,CPARTS,CCONDM
         IF(INTANA.EQ.1) GO TO 1000
         WRITE(NPRNT,23)CANUMA,CTOMAN
         GO TO 1050
 1000    WRITE(NPRNT,24)CANUMA,LFT,CTOMAN
 1050    WRITE(NPRNT,25)CTOILC
C
 1100 Y(NN)=CTOILC
 1150 CONTINUE
 1200 CONTINUE
C
C***** CHECK FOR PLOT
C
      IF(NPLOT.EQ.0) GO TO 50
C
      IF(NSEL.EQ.2) GO TO 1250
         WRITE(NPRNT,28)
      GO TO 1300
 1250    WRITE(NPRNT,29)
```

```
C
 1300 NN=0
      DO 1350 K=1,NM
      DO 1350 J=1,NH
         NN=NN+1
         JJ=NH+1-J
         WRITE(NPRNT,31)X(JJ),IC(K),Y(NN)
 1350 CONTINUE
C
      CALL PLOT(NM,NH,NN)
      GO TO 50
    1 FORMAT(5I5,F6.2)
    2 FORMAT(8F10.5)
    3 FORMAT(I1)
    4 FORMAT(I1,2F5.2)
    5 FORMAT(//11X,≠DATA UNIQUE TO DEVICE :≠,T77,≠CONDITIONS :≠)
    6 FORMAT(14X,≠BASE LABOR HOURS TO REPAIR≠,T54,F6.2,/,14X,≠DEPOT HOUR
     1S TO REPAIR≠,T54,F6.2)
    8 FORMAT(14X,≠MEAN FLT. HRS. BETWEEN DEMANDS≠,T48,F12.2,T80,
     *≠ REMOVAL IS FLIGHT HOURS DEPENDENT.≠)
    9 FORMAT(14X,≠MEAN MONTHS BETWEEN DEMANDS≠,T48,F12.2,T80,
     *≠ REMOVAL IS CALENDAR MONTHS DEPENDENT.≠)
   10 FORMAT(14X,≠NO. OF DEVICES INSTALLED≠,T52,I5,T77,≠STANDARD DATA:≠)
   11 FORMAT(14X,≠NUMBER OF BASES≠,T33,≠CONUS≠,2X,I3,5X,≠OVERSEAS≠,I3)
   12 FORMAT(14X,≠UNIT COST IN DOLLARS≠,T53,F7.2,T80,≠BASE HOURLY LABOR
     *RATE≠,T117,≠$13.03≠)
   13 FORMAT(14X,≠PARTS MAINT. COST, PCT OF UNIT COST≠,T55,F5.2,T80,≠DEP
     *OT HOURLY LABOR RATE≠,T117,≠$18.05≠)
   14 FORMAT(14X,≠BASE LABOR HOURS TO RMV/REPLACE≠,T54,F6.2,T80,≠DAYS TR
     *ANSIT DELAY, BASE-DEPOT≠)
   15 FORMAT(14X,≠PERCENT OF CONDEMNATION≠,T54,F6.2,T90,
     *≠CONTINENTAL U.S.≠,T117,F6.2)
   16 FORMAT(14X,≠PERCENT OF BASE REPAIR≠,T54,F6.2,T90,≠OVERSEAS≠,
     *T117,F6.2)
   17 FORMAT(14X,≠DAYS REPAIR DELAY, DEPOT≠,T54,F6.2)
   18 FORMAT(14X,≠DAYS REPAIR DELAY, BASE≠,T54,F6.2)
   19 FORMAT(14X,≠FLIGHT HOURS/DAY/DEVICE≠,T54,F6.2)
   20 FORMAT(14X,≠DAYS PROCUREMENT DELAY, DEPOT≠,T54,F6.2,
     1/,14X,≠ASSUMED YEARS LIFETIME≠,T54,I6)
   21 FORMAT(////////T31,≠COST OF INSTALLED DEVICES≠,T109,≠$≠,F13.2//T3
     *1,≠INITIAL INVENTORY COST≠//T39,≠EACH U.S. BASE  ≠,10X,I6,
     *≠ DEVICES≠,/,T39,≠EACH OVERSEAS BASE  ≠,6X,I6,≠ DEVICES≠,
     *//,T36,≠TOTAL INITIAL INVENTORY COST FOR ALL BASES≠,T109,
     *≠$≠,F13.2,
     *//,T39,≠DEPOT≠,T49,I6,≠ DEVICES ≠,T109,≠$≠,F13.2//T31
     *,≠ANNUAL MAINTENANCE COST FOR≠,I6,≠  REPAIRS≠,/)
```

```
22  FORMAT(T39,≠REMOVE/REPLACE LABOR≠,T69,≠$≠,F13.2/T39,≠REPAIR LABOR≠
   *,T69,≠$≠,F13.2/T39,≠PARTS COST≠,T69,≠$≠,F13.2/T39,≠CONDEMNATION CO
   *ST≠,T69,≠$≠,F13.2/T69,14(1H-)//)
23  FORMAT(T35,≠TOTAL ANNUAL MAINTENANCE COST≠,T69,≠$≠,F13.2,
   *//,T35,≠LIFETIME MAINTENANCE COST USING PRESENT WORTH ANALYSIS≠,
   *T109,≠$≠,F13.2,///)
24  FORMAT(T35,≠TOTAL ANNUAL MAINTENANCE COST≠,T69,≠$≠,F13.2,
   *T92,≠X≠,I3,≠ YEARS≠,T109,≠$≠,F13.2/T109,14(1H-)///)
25  FORMAT(T74,≠TOTAL INCREMENTAL LIFE CYCLE COST≠,T109,
   *≠$≠,F13.2)
26  FORMAT(80A1)
27  FORMAT(I2,F5.2,I1)
28  FORMAT(1H1,49X,≠TOTAL INCREMENTAL LIFE CYCLE COST≠//50X,≠UNDER DIF
   $FERENT BMH AND MTBD ARE:≠///50X,≠BMH≠,10X,≠MTBD≠,11X,≠CTOILC≠,/,
   $,50X,≠---≠,10X,≠----≠,11X,≠------≠/)
29  FORMAT(1H1,49X,≠TOTAL INCREMENTAL LIFE CYCLE COST≠//50X,≠UNDER DIF
   $FERENT DMH AND MTBD ARE:≠///50X,≠DMH≠,10X,≠MTBD≠,13X,≠CTOILC≠,/,
   $50X,≠---≠,10X,≠----≠,11X,≠------≠/)
31  FORMAT(49X,F5.2,3X,F12.2,5X,F13.2)
32  FORMAT(I2,2F6.2)
33  FORMAT(16X,≠WITH PRESENT WORTH AND INFLATION ANALYSIS,INTEREST RA
   *TE ≠,
   *F6.2,≠PERCENT, INFLATION RATE ≠,F6.2,≠ PERCENT≠)
34  FORMAT(51X,≠WITHOUT PRESENT WORTH ANALYSIS≠)
35  FORMAT(37X,≠WITH PRESENT WORTH ANALYSIS, INTEREST RATE ≠,F6.2,≠ PE
   *RCENT≠)
C
 1400 STOP
      END
```

```
      FUNCTION NPSSN(AVG,ALPHA,NDEVIC)
C
C***** FUNCTION NPSSN USES THE POISSON DISTRIBUTION TO
C***** CALCULATE AN INVENTORY LEVEL SATISFYING USER≠S
C***** DESIRED CONFIDENCE FOR MEETING DEMAND
C
      DIMENSION P(800)
C
      I=1
      P(1)=EXP(-AVG)
      SUM=P(1)
      IF(SUM.GE.ALPHA) GO TO 200
      DO 100 I=2,NDEVIC
         P(I)=P(I-1)*AVG/FLOAT(I-1)
         SUM=SUM+P(I)
         IF(SUM.GE.ALPHA) GO TO 200
 100  CONTINUE
C
 200  NPSSN=I-1
C
      RETURN
      END
```

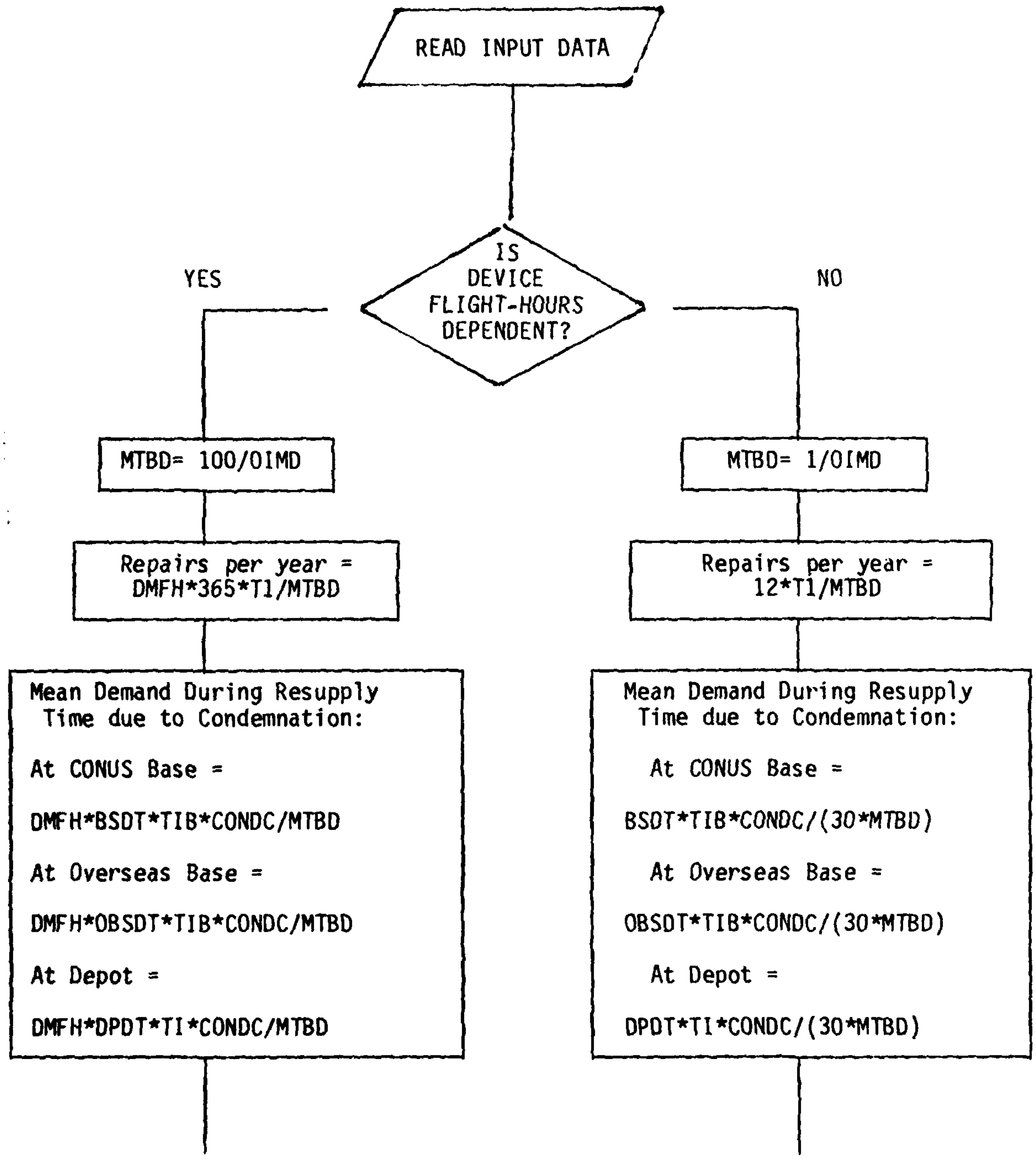
```
      SUBROUTINE TITLE
      COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
      INTEGER BLANK,INAME(130)
      DATA BLANK/≠ ≠/
C
      I=1
      NPRNT=6
      WHILE(NAME(I).NE.BLANK.OR.NAME(I+1).NE.BLANK) DO
         I=I+1
      ENDWHILE
C
      I=I-1
      NK=(133-I)/2
      DO 100 II=1,120
         INAME(II)=BLANK
  100 CONTINUE
C
      DO 200 II=NK+1,NK+I
         INAME(II)=NAME(II-NK)
  200 CONTINUE
C
      WRITE(NPRNT,20)
      WRITE(NPRNT,30)(INAME(II),II=1,120)
C
   20 FORMAT(1H1,T54,≠INCREMENTAL LIFE CYCLE COST≠//T66,2HOF/)
   30 FORMAT(120A1/)
C
      RETURN
      END
```

```
      SUBROUTINE INTRST
      COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
      COMMON/UCOM2/LFT,CTOMAN,CANUMA
      REAL IFR,INT
      IFR=IFR/100.
      INT=INT/100.
C
C*****PRESENT WORTH ANALYSIS WITH INFLATION
C
      IF(INTANA.EQ.2)GO TO 100
C
C*****CHECK FOR INTEREST RATE EQUAL INFLATION RATE
C
      IF(INT.EQ.IFR)GO TO 50
----------------------------------------------IS FLOATING POINT EQUALITY EXPECTED
      QUO=(1+IFR)/(1+INT)
      IEXP=LFT+1
      FNUM=1-(QUO**IEXP)
      FDEN=1-QUO
      FAC=FNUM/FDEN-1
      CTOMAN=CANUMA*FAC
      RETURN
C
C*****INTEREST RATE EQUAL TO INFLATION RATE
C
   50 CTOMAN= CANUMA * LFT
      RETURN
C
C*****PRESENT WORTH ANALYSIS WITHOUT INFLATION
C
  100 FNUM=((1+INT)**LFT)-1
      FDEN=INT*((1+INT)**LFT)
      FAC=FNUM/FDEN
      CTOMAN=CANUMA*FAC
      RETUPN
      END
```

```
      SUBROUTINE PLOT(IL,IV,N)
      DIMENSION IA(3),IP(91)
      COMMON/UCOM1/INTANA,INT,IFR,NAME(80)
      COMMON/UCOM3/ID,NSEL,X(10),V(10),Y(30),NPRNT,IC,NINPU
      REAL IC(3),IFR,INT
      DATA IB,IA/≠ ≠,≠$≠,≠~≠,≠→≠/
C
      SCALE=(Y(1)-Y(N))/40.0
      IF(IL.EQ.1)SCALE=Y(1)*2.
      WRITE(NPRNT,1)
      I=40
      M=(IV-1)*10+1
C
   15 DO 20 K=1,M
   20 IP(K)=IB
C
      DO 30 J=1,N
      IY=(Y(J)-Y(N))/SCALE+0.5
      IF(IY.NE.I) GO TO 30
      IF(J.GT.IV) GO TO 21
      IX=(IV-J)*10+1
      IP(IX)=IA(1)
      GO TO 30
C
   21 IF(J.GT.(2*IV)) GO TO 22
      IX=(2*IV-J)*10+1
      IP(IX)=IA(2)
      GO TO 30
C
   22 IX=(3*IV-J)*10+1
      IP(IX)=IA(3)
   30 CONTINUE
C
      IF((I/10)*10.EQ.I) GO TO 40
      IF(IP(1).NE.IB) GO TO 35
      WRITE(NPRNT,2)(IP(II),II=2,M)
      GO TO 60
C
   35 WRITE(NPRNT,3)(IP(II),II=1,M)
      GO TO 60
C
   40 YP=Y(N)+SCALE*I
```

```
      IF(IP(1).NE.IB) GO TO 45
      WRITE(NPRNT,4)YP,(IP(II),II=2,M)
      GO TO 60
   45 WRITE(NPRNT,5)YP,(IP(II),II=1,M)
C
   60 I=I-1
      IF(I.GE.0) GO TO 15
C
      WRITE(NPRNT,6)
      WRITE(NPRNT,7)(X(I),I=1,IV)
      IF(NSEL.EQ.2) GO TO 70
      WRITE(NPRNT,8)
      GO TO 80
   70 WRITE(NPRNT,9)
C
   80 DO 90 I=1,IL
         WRITE(NPRNT,10)IA(I),IC(I)
   90 CONTINUE
C
      WRITE(NPRNT,11)NINPU,NAME
C
    1 FORMAT(≠1≠/4X,≠TOTAL≠/4X,≠COST($)≠,/)
    2 FORMAT(13X,≠*≠,90A1)
    3 FORMAT(13X,91A1)
    4 FORMAT(1X,F10.0,2X,≠+≠,90A1)
    5 FORMAT(1X,F10.0,2X,91A1)
    6 FORMAT(13X,≠+≠,10(≠*********+≠))
    7 FORMAT(10X,10(F5.2,5X))
    8 FORMAT(≠+≠,110X,≠BMH(HR.)≠//)
    9 FORMAT(≠+≠,110X,≠DMH(HR.)≠//)
   10 FORMAT(/,22X,A1,≠ REPRESENTS MTBD=≠,F12.2)
   11 FORMAT(//,22X,≠FIGURE ≠,I2,≠.  ≠,80A1)
C
      RETURN
      END
```

APPENDIX D. FLOW DIAGRAM OF LCC-LSD ALGORITHM



Mean Demand During Resupply Time due to Repair:

At CONUS Base =

[DMFH*BSDT*TIB*

(1.0-PERC)*(1.0-CONDC)/MTBD]

+ [DMFH*BRCT*TIB*PERC/MTBD]

At Overseas Base =

[DMFH*OBSDT*TIB*

(1.0-PERC)*(1.0-CONDC)/MTBD]

+ [DMFH*BRCT*TIB*PERC/MTBD]

At Depot =

DMFH*DRCT+POSB*38.0)*TI*

(1.0-PERC)*(1.0-CONDC)/MTBD

Mean Demand During Resupply Time due to Repair:

At CONUS Base =

[BSDT*TIB*(1.0-PERC)*

(1.0-CONDC)/(30*MTBD)]

+ [BRCT*TIB*PERC/(30*MTBD)]

At Overseas Base =

[OBSDT*TIB*(1.0-PERC)*

(1.0-CONDC)/(30*MTBD)]

+ [BRCT*TIB*PERC/(30*MTBD)]

At Depot =

DRCT + (POSB*38.0))*

TI*(1.0-PERC)*

(1.0-CONDC)/(30*MTBD)

Use Poisson distribution (or normal distribution if demand during resupply time >50) to calculate initial inventories that are sufficient with probability SIGMA.

Calculate costs of initial inventories

Calculate costs of installed devices

Calculate annual maintenance cost

Sum to obtain total incremental life-cycle cost

Print results

STOP

LIST OF DEFINITIONS

A = Yearly payment, or annuity (cost of repairs and new items)
AFLC = Air Force Logistics Command

BCOND = Average number of condemned items at base at any time
BCONDO = Average demand per overseas base due to condemnation
BCONDU = Average demand per CONUS base due to condemnation
BLR = Base labor wage rate per hour
BMC = Cost of repair parts or kits (as a percent of unit cost)
BMH = Base man-hours required to repair item
BRCT = Time from removal of item until repair at base is complete (days)
BRPB = Average number of items undergoing repair at base at any one time
BRPD = Average number of items moving between a base and depot for repair at any one time
BSDT = Time from CONUS base requisition to receipt of new item from depot (days)

CANUMA = Total cost of annual maintenance
CCONDM = Annual cost of condemnation replacement
CINIBS = Cost for filling inventory at base level when initiating new system
CINID = Cost for filling inventory at depot level when initiating new system
COND = Condemned items (as percent of total demand)
CONDC = Fraction of demands that are condemned
1-CONDC = Fraction of demands that are repairable
CONUS = Continental United States
CPARTS = Annual repair-parts cost (no parts for condemned items)
CRANDR = Annual remove-and-replace cost
CREPB = Annual cost of base repair (condemning and repairing items at base
CREPAR = Cost of repair labor
CREPD = Annual cost of depot repair
CTALLD = Cost of installed items (No. of item X unit cost)
CTOILC = Total incremental life-cycle cost
CTOMAN = Total maintenance cost, over all lifetime

DCOND = Average number of items on order by depot at any time to replace base-condemned items
DLR = Depot labor wage rate per hour
DMFH = Flight-hours per day per device
DMH = Depot man-hours required to repair item
DMND = Monthly rate-demand
D039 = Computation system - Equipment item requirements, recoverable, serviced at base (anti-G suit)
D041 = Computation system - Recoverable consumption item requirements (oxygen regulator and valve)
D062 = Computation system - Economic order quantity buy, unrecoverable items (oxygen mask and connector)
DPDT = Time from requisitioning an item from supplier to receipt at depot (days)
DRCT = Time for items to be sent to depot, repaired, and ready for reissue: DRCTU, from CONUS bases; DRCTO, from overseas bases
DRPD = Average number of items undergoing repair at depot at any time

EOQ = End of quarter

FREQCY = Integer part of PP

i = Annual interest rate
i_f = Inflation rate
i_r = Interest rate

ID = Demand index: ID = 1, flight-hours dependent
ID = 2, calendar-months dependent
IFR = Annual inflation rate as a percent
INT = Annual interest rate as a percent

LAMDAD = Average demand at depot
LAMDBU = Average demand per CONUS base
LAMDBO = Average demand per overseas base
LCC = Life-cycle cost
LCC-LSD = Life-cycle cost model for life support devices
LFT = Assumed lifetime of device, in years
LSC = Logistics support cost

M = No. of bases using item (MO, overseas; MC, CONUS)
MTBD = Mean time between demands (reciprocal of OIMD)
MTBF = Mean time between failures

N = No. of years

OBSDT = Base-depot transit delay (overseas) in days
OIMD = Demand rate for item (per 100 flight-hours or per month, depending on item)

PDM = Programmed (periodic) depot maintenance
PERC = Fraction of repairs done at base
1-PERC = Fraction of repairs done at depot
PERCNT = Percent of item repairs that can be done at base
PFFH = Peak force flying hours (expected fleet flying hours for 1 month during the peak usage period)
POSB = Fraction of bases that are overseas bases
PP = Repairs per year
PW = Present worth
PNT = Fraction of original value by which BMH or DMH decreases with each run

RKIT = Cost of repair parts of kits
RMH = Man-hours required to remove and replace an item at base

SIGMA = Confidence coefficient for inventory
STKBO = Initial inventories needed at overseas base
STKBU = Initial inventories needed at CONUS base
STKD = Initial inventories needed at depot

TI = Total number of items installed
TIB = Total items per base (TI divided by M)

UC = Unit cost of item

ILMED

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